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MAY, 1939

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WHY ATTEND THE ANNUAL MEETING?

By F. L. BISHOP

Secretary

Another annual meeting of the Society will be held June 19–23, 1939, at The Pennsylvania State College, State College, Pa. Probably between 1200 and 1800 members and guests will be in attendance. Why do they come? Have you ever stopped to analyze the motives of so many teachers who attend these meetings? Some travel many weary miles. Many come from short distances or have made the long trip in easy stages. They sit beside you at the meetings. They talk to you and to others. They listen to the speakers present new points of view. They take part in numerous conferences.

Do you wonder why so many teachers attend these meetings? They come to learn how to improve their teaching! What do they expect to take away? They cannot tell you in so many words but if you watch their teaching when they return to their classes the improvement which is evident shows you what they have taken away. It is there, in the classroom, that they put into action the things which they have learned at the meeting. Many pet ideas in regard to certain methods are thrown into the discard because these teachers are cognizant of new trends in education and in training. It is at these meetings that many new contacts are made which lead to promotions to other institutions. To extend one's acquaintance with members from other educational institutions pays well for the time and expense involved.

These, I think, are some of the opportunities which present themselves to those who attend our annual meetings. The inspiration to "carry on" even better for the coming year is possibly the great contribution which the annual meeting has to make to each and every one who attends.

REPORT: PROGRESS IN ENGINEERING EDUCATION

1938

Society for the Promotion of Engineering Education

Note: This fourth annual Progress Report continues the record of significant trends, developments and events in engineering education. Former reports have appeared in the JOURNAL OF ENGINEERING EDUCATION, February 1936, April 1937 and June 1938.

What is a Progress Report—this Report? It is a resume of responses from our leaders, our Officers and Chairmen, to a request for noteworthy items of the past year and also for significant trends over a period of years. Sixty pages from half as many contributors presenting over a hundred topics have been epitomized. The Committee does not formally "endorse" the views but edits and coordinates (puzzle-picture fashion trying to fit scores of bits into an orderly pattern) and presents the comments of activity leaders and of past presidents for information and stimulation. The report is selective, not exhaustive; the topics are those our leaders emphasize. The Committee however decided to make "evidence of progress" in engineering education the criterion of what should be included. This eliminated a score of selected news items and discussions.

TREND FROM BASIC RESOURCES TO APPLICATION AND USE; SOCIAL PROGRESS

Enrollments indicate a shift in curricula from those related primarily to the development of natural resources (materials and power)—mining, civil and electrical—to those serving industry—chemical, industrial, mechanical, metallurgical. This accords with natural evolution—discovery, invention, design, development, application, use. Thus, in the beginning of modern industry men were needed primarily to develop in the office and in the shop new appliances to meet the specific needs of industry itself in processes and machinery and methods. As products became established there followed their application in wider fields of use with emphasis on the consumer. Thus, pioneer dealing with basic resources is followed by the application and use of engineering products. (Hence also the social implications of extending use.) Advancing industry's need for new types of men and the changes in curricular

enrollment are interrelated in a common mutual stimulus and evolution.

Able designers and competency in routine are essential but the greater need is for minds that have not been routinized or standardized by academic procedures, but through individual development of natural talents are keen to do new things in new ways. "Industry has standardized its production methods, its product; it trains standardized college graduates along lines that standardize their thoughts. What is needed is men of individual superiority to invent and develop new things." And men of the engineer-salesman type to adapt them to serve the public interest. New social situations also call for trained specialists; some of these are noted in connection with graduate work.

Social Progress.—Two clarifying presentations by President Compton put engineering in larger perspective. "Engineering Education and Social Progress"—a keynote sounded at the beginning of the year—in the September JOURNAL, and "Instruments of Social Progress" in December.

INVESTIGATIVE PHASES OF ENGINEERING SCIENCE

The recent emphasis on the investigative phases of engineering science indicate distinctive progress in engineering education. Before the coming of engineering experiment stations, engineering was "applied science"—a term becoming obsolete. Partly an art as modified by science, it is also a science, both investigative and applied. Papers in engineering society publications two decades ago were of the applicatory sort, today they are of the theoretical type, indicating a fundamental change in the engineering education which these papers reflect. Curricula have shifted toward the theoretical, away from field and shop details, which are left to the early years of practice. Graduate study with research is being evolved for capable students.

Supporting Evidence of Investigative Trend.—(*a*) Hydraulic laboratories for the study of complicated hydraulic problems; at Minnesota, Florida, Manhattan College, the University of Washington.

(*b*) Advance in the knowledge of stress distribution in continuous frames and in simplified methods of analysis; following the epochal paper by Hardy Cross, are papers by Grintner, Lin, Stewart and others (Am. Soc. C. E.).

(*c*) Wider application of the Schlieren optical method of photographing density gradients in compressible fluids to problems in aerodynamics, heating and ventilating, heat transfer, turbine blade and nozzle design, and jet compressor design. Under proper con-

ditions the method is capable of quantitative as well as qualitative results.

(*d*) Discontinuance of mining engineering at M. I. T. and elsewhere. At Lehigh there is new emphasis on the business of mine management.

(*e*) The separate course in sanitary engineering as such, has been dropped at M. I. T., Lehigh, Illinois, Iowa and elsewhere, the content being reabsorbed in Civil Engineering. "Biological Engineering" has appeared.

(*f*) Chemical Engineering has been strengthened at Cornell, Pennsylvania and other institutions.

(*g*) Tensor analysis is being applied to electric circuits and machine theory; corresponding to "complex quantity" by Steinmetz and "symmetrical components" by Fortescue. Dr. Kron's volume is notable.

(*h*) The program of our Committee on Engineering Research, for stimulating interest (Mar. '39, pp. 501–538) *.

Cultural and Professional Phases of Engineering Education

This subject of President Earle's address at the Texas meeting strikes the keynote of our 1938 Convention. The aim was to bring together the best thought of engineering educators and practicing engineers and create an interest which will lead teachers to stimulate an intelligent interest by students. His presentation closes with the virile suggestion that teachers "may do considerable instruction themselves along with the teaching of their engineering subjects" (Sept. '38, p. 12).

President Walton, of the A. & M. College of Texas, host to the convention, said college presidents and teachers too often feel that if they have developed a great technical engineer they have discharged their whole responsibility but "we now know that we have an obligation for the performance of our product, for the influence of his life upon society" (Sept. '38, p. 26).

All this indicates that the broader ideals in engineering education take a leading place in the Society's aims.

Cultural Phase of Engineering Education.—This was the topic of three papers and a worth while discussion (Oct. '38, pp. 92–120).

President Calhoun, of the University of Texas, began by saying, "This topic is truly appalling in its length, breadth, depth, complexity and obscurity. It has at least five dimensions."

Dean Kimball opened thus, "All thinking engineers and engineering educators agree that if the profession is to rise to its highest usefulness and consequently to its highest public appreciation,

* Reference to JOURNAL OF ENGINEERING EDUCATION.

the curricula of the engineering colleges must be considerably broadened."

Dean Seaton said that the presentation of the cultural phase and of the professional phase by different groups seemed to make them distinct and unrelated. "In my opinion the cultural and professional phases of engineering education are closely interrelated and the cultural phase is just as necessary to the attainment of true professional status by the engineer as is the professional phase."

In these papers and their discussion by J. B. Thomas, Professor C. W. Crawford and Dean E. A. Holbrook there is a vital summing up of the situation. (See "Engineers as Leaders" by Prof. Doan (Dec. '38, p. 275).)

Professional Phase of Engineering Education.—Four significant papers were presented (Oct. '38, pp. 137–155).

Dean Potter deals with the vital question of just what attributes characterize the professional status and the necessary qualifications of the student.

Dean Woolrich gives the historical background of the development of the profession and considers the relation of the engineer to the social sciences.

Mr. Eshbach vividly presents the industrial viewpoints and concludes that united efforts of all engaged in the profession are essential if we are to solve the problems at hand.

Dean Gilchrist, in discussion, reviews the papers and concludes that a broader general education planned principally by engineers will give the graduate a better start.

Registration.—The fourth paper was by Dean Daggett and presents a problem which confronts the engineering profession and engineering educators. A factor of far-reaching importance is the engineering registration laws now effective in five-sixths of the states. "The only gateway for admission to the engineering profession in the states which have comprehensive registration laws is by proper certification by the state boards." He points out that in about half of the registration states there has been organized a State Society of Professional Engineers under charters granted by the National Society of Professional Engineers composed wholly of registered engineers (but independent of the Registration Boards). He quotes from the handbook used by the largest of the state societies, "The only agency that can admit a man into the Engineering Profession is the legally authorized State Board. Membership in an engineering society does not make a man an Engineer."

He further quotes a speaker at the preceding convention of the National Society: " 'I think that one of the objects of our society should be that of furthering the proper education of engineers, to take charge ultimately of engineering education in the United

States to the extent that the Medical Association has taken charge of the supervision of medical institutions in this country.' . . . To which the president of the society replied—'I might say that these recommendations are fairly well advanced in the councils of the society. . . . We hope that the time is not far distant when there will be established such standards for entrance into the profession as will make it possible to ascertain who has the best chance and also what the institutions of learning should teach.' "

Dean Daggett continues, "The avowed objective of the society is to make engineering a definitely closed profession. . . . If engineering is to become a closed profession, then it is only logical that engineering education should abandon its present dual objective. Engineering schools will exist solely for the purpose of supplying the necessary recruits for the profession. The curriculum will be one of five or six years; the number of schools needed to supply the demand perhaps not more than half the present number; and the cost to the individual and to society for the necessary educational foundation very materially increased."

It may be noted that in the State of New York the society has sponsored the introduction of an Act in the Legislature making provision for two years of college academic training preceding the four-year engineering course as a preliminary to registration. Such measures may have a far-reaching effect upon the curricula of engineering schools; it would make a specific change in engineering education without a comprehensive study of the best means of increasing the educational program if it is to be extended. The old-time freedom of the schools and the recently established participation in educational standards through accrediting by the joint action of the professional societies, the engineering schools and the National Council of State Boards of Engineering Examiners in their common affiliation in Engineers' Council for Professional Development, which presumably is the instrumentality for dealing with their common problems—all this is cast aside as another group undertakes, by legislative fiat, to dictate what engineering education is to be. This raises some fundamental questions in the whole engineering perspective. Is engineering education, as it has developed a common background for the engineer who is to practice professionally and the engineering graduate whose training fits him for semi-professional and administrative duties, to be scrapped and a new regime forced upon the engineering schools? Are Legislatures to enact curricula?

Increase in Graduate Work

The enrollment for advanced degrees has doubled in about a decade and now exceeds 5,000 in 75 schools. Seven of these (all

in large cities) have from 200 to 700 students and enroll half of the total, while over a third have less than ten students each. More than a quarter of the enrollment is in evening courses. In Metropolitan New York 80 per cent of approximately 800 students attend in the evening (Jan. '39, p. 376).

Graduate work is credited with changing the point of view of faculties and of influencing undergraduate curricula. It is one way to extend engineering education. Concern is expressed for the quality of advanced work where facilities and staff are limited. Strong and well equipped science and mathematics departments are deemed essential.

Graduate Work for Industry is Challenged.—The value of postgraduate training for all who enter industry was questioned by L. W. W. Morrow at the December meeting of the Mid-Atlantic Section. He quotes a director of research and development in a large manufacturing company, "It is foolish for engineering colleges to give graduate work. We need a few men with advanced training each year. . . . We need graduate scientists, not graduate engineers." A director of engineering says, "We prefer to take four-year men and train them by our own specialists." Another says that for the design and development of complicated machines "We do not need postgraduate engineers." Morrow says that these comments are not competent or conclusive and there is a much broader perspective than they exhibit, yet if these are the opinions of some employers they merit attention by our educators. The paper concludes, "This discussion, it is hoped, will start a program of investigation rather than develop conclusions. . . . Our critical times and changed conditions offer every possible inducement to engineering educators and to industry to train and equip our young people to meet the needs of civilization to better advantage" (*Electrical Engineering*, Mar. '39).

It may be recalled that the "Wickenden" investigation indicated that the volume demand of industry was best met by four-year graduates who at once transferred to the school of experience. But that is not the only requirement by industry nor is industry the only field for engineering graduates. Should graduate work for men in industry follow graduation immediately or in later years?

A Graduate Coöperative Program with Westinghouse Electric and Manufacturing Company (similar to the one with the University of Pittsburgh) in the metropolitan area, including New York University, Stevens Institute and Polytechnic Institute of Brooklyn, in one common plan is to be inaugurated in 1939–40. Employees of the company may earn credit in the Westinghouse courses toward advanced degrees. Courses under direction of

Westinghouse lecturers affiliated with the three institutions will be available also to regularly enrolled students.

Comprehensive Graduate Courses on the fundamentals of Engineering Sciences as a basis for constructive research will be offered by the Polytechnic Institute of Brooklyn next year. The five subjects are: Fundamental Mechanics; Radiation; Electronics, Statistical Mechanics and Quantum Mechanics.

Pioneering in the Graduate Field.—"Every new social problem brings its own challenge to universities. Facilities must be reorientated and expanded to answer new demands if education is to serve society." New conditions created by engineering bring new problems to which graduate study may contribute. Two examples are now cited:

For Industrial Executives at M. I. T.—Fellowships for industrial executives at Massachusetts Institute of Technology have been established by the Sloan Foundation for emphasizing the responsibility of executive officers to society and directing critical thought upon the essential influences bearing upon industrial administration. This is most significant; after the application of engineering sciences to industry, we are now confronted by the problem of developing a managerial control and an executive direction which will distribute the fruits of industry more widely to labor and to society.

Traffic Research at Yale.—Street and highway traffic control is a twentieth century innovation, outcome of a new type of engine and a phenomenal engineering development. One problem of the "automotive revolution" is traffic control. The estimated potential number of traffic engineers is 1,500 while those now listed are but a third of that number, of which twenty per cent have received training in the Bureau for Street Traffic Research. The Bureau was established at Harvard a dozen years ago and has recently been transferred to Yale. The students selected are in general engineering graduates as "his course has given him a factual approach; it indoctrinates him with a spirit of accuracy; it gives him a command of mathematics and statistics, also a reasonable knowledge of structures and qualifies him personally to deal with the engineering personnel with whom, as traffic engineer, he will be associated." There are nineteen graduate scholarships, carrying a stipend of $1,400.

The development of courses for any emerging profession represents slow and painstaking work. In common with other fields of engineering education, it is pioneering and progressing.

Some Society Activities

The Annual Convention at the A. & M. College of Texas had an enrollment of 984, exceeded only by a few recent conventions.

Satisfaction with the hospitality of the hosts is expressed in eleven resolutions adopted by a rising vote. Particulars are given in the Minutes of the 46th Annual Meeting and of the Council meetings published in our September JOURNAL.

The Secretary's Report, in the same issue, summarizes the activities of the year. The membership reached an all-time peak of 2,795 individuals and 137 institutions. Nearly 400 members were elected during the year, exceeding the total membership in 1905. The report includes these items: Meetings, Divisions, Progress, Institutional Delegates, Publications, Employment and Problems. The latter relate to the 5 vs. 6 year program and to labor unions. (See "Engineering Schools and Labor Unions," V. T. Boughton in March '39, JOURNAL, p. 475.) Reports of a score of conferences are printed in the November JOURNAL.

The Lamme Medal was awarded to R. L. Sackett, primarily for coördinating the thought of engineering and of industry. He was a potent factor in Pennsylvania as Dean of its State College, and his keen interest and effective accomplishment in engineering continues with E. C. P. D. Incidentally, of the 11 recipients of the Society's Lamme Medal, 8 have been Presidents of the Society (Sept. '38, p. 1).

English.—A report upon instruction in English in engineering colleges, which is the result of a study financed by a grant of $2,500 from the Carnegie Foundation, is being published serially in the JOURNAL. It deals with "educational problems of exceptional interest" and outstanding importance may do much for the teaching of English and it should be the forerunner of similar studies of other problems.

Economics.—There has been definite growth in the number of courses dealing with this subject during the past five years. Engineering teachers are realizing that their problems must be solved in dollars as well as in technical units. A course of this type gathers students as time goes on. Such courses are also given as extension work for graduates, which is promoted by the requirements of state registration boards.

Production Engineering.—Scrutiny is directed to the place of shops in engineering education. There has been a continuing trend away from craft instruction toward emphasis on modern materials and methods. This year, for instance, at Arizona the traditional type of instruction has given place to production engineering in which materials, methods, the suitability of use and design, tool life and economics of production are main objects.

EDUCATIONAL COMMENT

"The Social Paradox" (more technology is essential for employment and prosperity, but more technology threatens to in-

crease social confusion) presented by President Doherty of Carnegie Tech is receiving attention through the aid of a $200,000 grant from the Falk Foundation and the acquisition of W. E. Hotchkiss, former President of Armour Institute of Technology, in a "planned education supported by both technological and social research." A noble experiment in broadening the engineer.

The Land Grant Colleges have received a recommendation from the Commissioner of Education to enquire as to their success in fulfilling their triangle of research, campus instruction and adult education. His further suggestion of research into the methods of instruction at the university level has been undertaken by the University of Arizona and presumably other institutions.

The Trend Toward the Engineering Profession.—A new professional consciousness is awakening and raising new questions as to the scope and content of professional engineering and of the educational preparation for it.

The Five-year vs. the Four-year undergraduate curriculum receives perennial discussion. Some of the questions involved are—the particular objects sought in the enlarged education; the practicability of improving the four-year schedule; can the objectives be best attained by lengthening the present course or by preliminary academic study or by graduate courses? Accrediting insures a quality in our normal courses; but are these courses adequate for coming conditions and to what extent will a common mold serve as preparation for the various activities of engineering graduates?

The Trend in Engineering Education.—No, it is not *the* trend; there are many trends and cross currents. The problem of the cultural phases alone is said to be one of five dimensions; the whole problem has many more.

North Carolina has consolidated its engineering work by transfer from Chapel Hill to Raleigh, thus insuring a single strong engineering body. This is regarded as the first move toward consolidation among the states which have divided their engineering work among several institutions.

Regarding Curricula

Trends in curricula seem to be still further toward simplification and concentration on essentials. Also a tendency toward fewer courses in each semester; at Yale, for example, five, while Brown has established four. There may have been local causes for these changes but the shift is significant.

Greater generalization is taking place by the introduction of humanities and non-technical or cultural subjects up to 25 per cent of the four-year curriculum.

Industry.—Greater emphasis should be placed upon engineering education as a broad preparation for industrial activity. Harvey N. Davis does a nice job of explaining this matter but there should be other heavyweights assisting him.

Social Sciences.—An outstanding change is the attention and study being given toward inclusion of more of the social sciences especially relating to labor relations. There is also increased interest in the study of economics.

A course in Basic Engineering at Princeton is a new four-year program preparing for many forms of business and also for two years in graduate work for those desiring to become technically qualified engineers.

The Basic Division at North Carolina State College serves as a "lower division" and a "general college" in attempting to solve the problem of orientation and preparation for highly specialized technical and professional fields.

Vocational Work is being conducted by the Federal Government in institutions of higher learning; through the Civil Aeronautics Authority aviation or flight schools have been established in 13 institutions. Thus a vocational course is open to engineering students.

Engineers Council for Professional Development

In the Annual Report the Chairman notes progress as he takes as the keynote: E. C. P. D. as a Continuing Permanent Agency. The first five years have been pioneering in which the projects undertaken have been proved to be valuable, continuing and enlarging. In accrediting our printed lists are not the end of the road but the first milestone on a new highway. Of many reports by those participating in the accrediting work the following is selected as significant. "Visits were an inspiration to inspectors and inspected, a stimulus to colleges with high grade curricula and a prod to those not up to a reasonable standard, an alarm clock to some faculties, a yardstick for trustees and regents, a guide to students and their parents, altogether a wise procedure, and should be continued."

Pre-Freshman Selection and Guidance.—Definite progress is noted in the interest and activity of preparatory and high schools in extending information and counsel.

After Graduation, What?—The critical period in the life of an engineer follows graduation in the "school of experience." Our profession has but few years in school and depends primarily on experience. E. C. P. D. is concerned, in contributing through various agencies, notably the engineering societies, in guiding and

assisting the young engineer. Through its initiation an article on "What is Engineering Experience," appears in the April, 1939, publications of the Civil, Mechanical and Electrical Societies.

The 6th Annual Report covers the topics which have been briefly sketched, and much more. The addresses at the annual dinner by Wickenden, Compton, Davies, Doherty, Rogers, Kimball and Jewett give a broad perspective of the present engineering situation including trends.

H. W. BIBBER,
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CHAS. F. SCOTT, *Chairman.*

HEAT AND THE FIRST LAW *

By JOSEPH H. KEENAN

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a. Rationalizing the First Law

The First Law of Thermodynamics is commonly called the Law of Conservation of Energy. It was first enunciated about the middle of the last century, but the concept of energy conservation was not new even then. About 150 years before, Newton had discovered the laws of motion from which it could be shown that "if, in any system of bodies, the force which acts between any two bodies is in the line joining them, and depends only on their distance, and not on the way in which they are moving at the time, then if no other forces act on the system, the sum of the potential and kinetic energy of all the bodies of the system will always remain the same." † Moreover work done by forces external to the system caused an increase in the sum of the potential and kinetic energies exactly equal to the work. The system described above was known as a *conservative system*. No single instance of a conservative system was known to exist, and for every known system of bodies for which the kinetic and potential energies could be evaluated, a given amount of work resulted in a lesser increase in the energies. Consequently, this Newtonian principle of conservation of energy could hardly be termed a general law of nature.

With the discovery of the interconvertibility of work and heat it was found that a conservation principle could be stated for all systems in nature; and it followed naturally that the new principle should be rationalized by postulating that all systems in nature are so-called conservative systems whose constituent bodies are too small to be readily discerned. Clausius, for example, in his book entitled "Mechanical Theory of Heat," published in 1875, writes the equation

$$dQ = dH + dL,$$

where Q is heat "imparted" to the body, H is the kinetic energy of the molecules or constituent bodies and L is a *work* term. The

* Presented at the meeting of the New England Section, S. P. E. E., at the University of Maine, October 8, 1938.

† Maxwell, "Theory of Heat," Appleton (1885), 92.

differential of L he subdivides in accordance with the equation

$$dL = dJ + dW,$$

where W is the work done on the system by external forces and J is the potential energy or stored work of separation. He points out that the state of a system is a function of the nature and magnitude of the motion of the molecules, and that, therefore, the integral of dH vanishes for any cyclic process. Next he proves by questionable reasoning that the integral of dJ also vanishes for any cyclic process, and therefore the First Law may be stated in the form

$$\oint dQ = \oint dW,$$

where the symbol $\oint$ denotes integration through a cyclic process. Lord Kelvin took a similar view, namely, that the First Law of Thermodynamics requires rationalization on the basis of the more familiar Laws of Motion.

The simple form of the corpuscular theory of matter evoked by Clausius is a part of the kinetic theory of gases which predicts the properties of certain gases at very low pressures with amazing precision. It fails, however, when applied to any known vapor at moderate pressures and is utterly inadequate when applied to liquids and solids.

One might still defend the H and J of Clausius on the grounds that all energy stored within a system can ultimately be accounted for by kinetic energy of minute particles or by potential energy of separation of those particles in a force field. The fact that liquid water below 4° C. will rise in temperature with adiabatic expansion does not dismay the stalwart defendants of this point of view, because, they point out, the potential energy is unconventional in this instance and decreases with increasing distance, thus releasing more kinetic energy than is used up by the work of expansion. The case of expansion of gases with rise of temperature during combustion in, for instance, an internal combustion engine cylinder is more formidable. Now our defenders of the H and J divide into two schools: the first explains the phenomenon in terms of chemical energy—a concept which no one seems willing to define quantitatively, so that we exchange a new mystery for an old one; while the second and more consistent school explains that the potential energy has only apparently increased, but that as a matter of fact the potential energy of particles inside the previously recognized particles has actually decreased enough to supply the increase of the first kind of potential energy, and in addition an increase of kinetic energy of all the parts and some external work. Henceforth we know how to explain all discrepancies—we merely postulate smaller particles within the smallest previously recognized. This is the

story of the fleas ad infinitum with a terrifying addendum to the effect that the smaller the flea the more powerful he is. If the concept that all matter is made up of conservative systems of the Newtonian type, is a law of nature, it is a deplorably awkward one.

The First Law of Thermodynamics is, on the contrary, a thing of grace and simplicity. It is perfectly general as regards systems that are large relative to the molecule. The absurdity of proving it by appeal to a principle which is either limited in application or unlimited in license has been recognized explicitly and implicitly by eminent authority. For example, Planck in 1897 said that his method of expounding thermodynamics "does not advance the mechanical theory of heat, but, keeping aloof from definite assumptions as to its nature, starts direct from a few very general empirical facts, mainly the two fundamental principles of Thermodynamics." *

b. The Nature of Heat

Let us return to Clausius' First Law equation, namely,

$$dQ = dH + dJ + dW.$$

Here H denotes what Clausius calls the "Quantity of Heat" of the system: the kinetic energy of the ultimate particles of matter; while J denotes their potential energy of separation and W the work done by macroscopic external bodies applying discernible forces to the boundaries of the system. The quantity Q, on the other hand, is not so easily described in similar terms. Clausius calls it the "heat imparted" to the system, which implies kinship with H. Lacking any description of Q in terms of the ultimate particles we may seek enlightenment from a description of a method of measuring it. We find that it is something which enters or leaves the system by virtue of a temperature difference between the system and its environment, and that it can be measured in terms of the mass of a prescribed substance that will pass through a prescribed temperature interval as a result of it.

Now there can be no objection to the application of the Clausius equation as stated above to a hypothetical system of mass points which has the appropriate characteristics. But Thermodynamics is more truly a science of the real and the complex than of the simple and the hypothetical. For real systems only two of the quantities in the Clausius equation, namely, Q and W, can be evaluated. The other two, H and J, cannot be evaluated separately for a real system by any known methods of measurement. Nor can they be deduced from any measureable quantities. Quantitatively, at least, they are utterly unsubstantial. And yet it is strangely true that it is

* Max Planck, "Treatise on Thermodynamics" (trans. by Ogg), Longmans (1927), viii.

the engineer, the practical man of science, the champion of the concrete against the abstract, who has kept these ghosts stalking through the literature of thermodynamics.

The purpose of the concepts H and J as employed in engineering texts appears to be to explain the connection between the state of a system and the quantity of energy stored in it: to explain why the internal energy is a property. But invariably there is also included a statement of the Law of Conservation of Energy (the First Law), which makes the explanation superfluous. For, the simplest statement of that law is

$$\oint dQ = \oint dW,$$

which when transposed to the form

$$\oint dQ - \oint dW = 0$$

becomes, by the definition of internal energy, an adequate statement that internal energy is a property.

Clausius and Kelvin were more logical. They employed H and J to rationalize the last statement, not to supplement it. It is probable, however, that both Clausius and Kelvin were aware that the rationalization was superfluous. Clausius, for instance, never once refers to his mechanical model or to H and J after his introductory chapter. Doubtless his method was a wise one. To his readers the First Law was new and the Newtonian Principles were familiar. To explain the new in terms of the familiar may be justified as pedagogy even if it is inadequate as proof.

Today the engineering undergraduate is seldom so thoroughly drilled in Newtonian mechanics and seldom so prejudiced in its favor as to require careful weaning before he is fed a new science. Nevertheless, his introduction to thermodynamics is in many instances through the H and J of Clausius which he soon decides are the things that work and heat turn into; and he often comes to feel that if only he concentrates his attention on molecular concepts until he can properly classify the energy entering a system into potential energy on the one hand or kinetic energy on the other he will have mastered thermodynamics. He does not realize that in difficulty of accomplishment his objective is worthy of God alone; nor does he know that his hopeless quest is too exacting to permit a deflection of interest toward the real truths of thermodynamics.

Of less consequence than their effects on teaching, but of some historical interest, is the effect of the concepts H and J on the names given at various times to the internal energy, the differential of which is evidently equal to the sum of dH and dJ. Clausius, in 1850, called it the "sum of the increment of heat actually existing and of the heat consumed in internal work," an awkward name and

a futile description. Kirchoff called it the "Wirkungsfunction" or "Activity Function." In 1860 Zeuner brought down upon himself the disapproval of the great Clausius by naming it "Interior Heat." Six years later he changed it in self-defense to "Interior Work," with no better results. Kelvin called it the "Mechanical Energy." In 1873 Clausius expressed his approval of Kelvin's term, but he adopted, fortunately, the abbreviated form "Energy." In the same year Gibbs published his first paper and used the latter term. It is still common in the literature, though the adjective *internal* is usually prefixed.

With the disappearance from thermodynamics of the H of Clausius, the so-called Quantity of Heat of a system, the need for the word heat in any connection except for the quantity Q, the Heat Imparted to the system, will also vanish. Planck says "since all calorimetric measurements . . . extend only to quantities of heat imparted to bodies or given out by them, they do not lead to any conclusion as to the total amount of heat *contained in* a body of given temperature. It would be absurd to define the heat contained in a body . . . as the number of calories absorbed . . . in its passage from some normal state into its present state." The absurdity he refers to should be familiar even to a beginner.

It may be inferred from his writings that Gibbs' conception of heat was similar to Planck's, though it was adopted much earlier. Without expressly defending his position, Gibbs never refers to a heat quantity that cannot readily be measured. Many years were to elapse after the appearance of the work of Gibbs and of Planck before the authors of American engineering texts became aware that the Heat of a System had been disposed of by eminent authority.

c. Heat of Friction

Unhappily, we are not yet entirely free from the concept of heat as a form of motion. In its most persistent form it appears as the *Heat Generated in a System by Friction*. It is easy to find numerous examples of the use of this term in engineering literature, but it has had one particularly eminent exponent in the present century: namely, G. H. Bryan, an English mathematician who, under German auspices, published a valuable treatise on Thermodynamics in 1907.* On page 72, following a list of irreversible processes such as friction between rough bodies, inelastic impact, etc., he says, "In the present cases the visible effects produced include an apparent absorption of mechanical work in the interior of the system . . . this lost work must reappear in the system in the form of some other kind of energy. We may define this energy as *heat generated*

* "Thermodynamics," G. H. Bryan, Teubner (1907).

internally in the system, the *quantity of heat* so generated being measured by the quantity of work lost." Here there is a redeeming footnote to the effect that this new kind of heat quantity denotes "something different from the 'quantity of heat' received by one body from another."

To use this concept of heat generated internally we must, in accordance with the definition, know how to determine the quantity of work lost. As regards friction between two bodies the lost work is found by executing the change of state reversibly with external forces substituted for the friction forces. The work done against the external forces is then the lost work of the irreversible process.

In a somewhat more general form Bryan's definition might be stated as follows: The heat generated internally is the lost work, which is in turn the excess of the work delivered externally by the system in a reversible process over that of the actual process if in both processes the system passes through the same series of states. It can be objected that it is impossible to fulfill the last requirement in those instances in which the system departs from equilibrium states in the irreversible process—for example, in unrestrained expansion of a fluid into a large evacuated chamber. Bryan himself recognized this difficulty with respect to diffusion of gases and chemical changes and he implies, therefore, that the concept is not altogether a satisfactory one.

For any series of equilibrium states we may, however, apply the definition of lost work, which we shall denote by ω. Thus

$$d\omega = dW_r - dW,$$

where dW_r and dW denote respectively the works of reversible and irreversible processes between two equilibrium states. By the First Law we may write

$$dW = dQ - dE,$$

where dQ is the heat received by the system from its surroundings during the actual or irreversible process and dE is the increase in internal energy of the system between the initial and final states. By substitution we get

$$d\omega = dW_r + dE - dQ,$$

and from the definition of entropy

$$dS = dQ_r/T = (dE + dW_r)/T,$$

where dQ_r is the heat received by the system in the reversible process. Substituting, we have

$$d\omega = TdS - dQ.$$

Thus, the "heat generated by friction" is the excess of the integral of Tds over the heat received by the system. In the adiabatic case it is simply the integral of TdS.

What good purpose this quantity ω can serve, it is difficult to discover. Certainly it permits no statement which would not be more lucid and more general if expressed instead in terms of the measurable quantities heat, temperature and entropy. Moreover its very name perpetuates the palpably false idea that something akin to heat in its measurability can be created and stored within a system.

Bryan's position is far more readily defended, however, than that of many engineers whose work appears in current literature. The following quotation is from a recent engineering publication: "It is impossible to complete an irreversible cycle on the temperature-entropy diagram unless $\int dQ/T = 0$ when taken round the cycle. So that in order not to leave a hiatus, dQ must represent all heat which affects entropy and includes heat generated by friction." Here is a definition of heat in terms of entropy; that is, $dQ = TdS$. From this point of view one who wishes to prove Q to be a measurable quantity will find the prospect forbidding.

d. Units

We have, then, two measurable quantities in terms of which all other quantities in thermodynamics must ultimately be defined: work and heat. The first may be defined as follows: *Work flows from a system (and to another) during a given operation if all effects of the operation external to the system could be completely converted into the rise of a weight.* It is measured by the magnitude of the weight which could be raised through a prescribed change in elevation. Heat may be defined as *that which passes between two systems of different temperature, whenever the two are brought into communication.* It is measured by the mass of a prescribed substance which it could change through a given temperature interval under given constraints.* It should be noted in passing that to incorporate the term *energy* into either of these definitions would add nothing to the measurability of the quantities.

Methods of selecting units of work and heat are implied in the descriptions of the methods of measurement just given. When appropriate units are selected the First Law may be most simply stated in terms of cyclic integrals in the form

$$\oint dW = J \oint dQ,$$

* It is assumed here that temperature can be defined in such a way that prescribed temperature levels may be identified. The definition is not within the scope of the present paper.

where J denotes a factor of proportionality. For any pair of commonly employed units of work and heat J will have a fixed value which may be determined by experiments on cyclic processes. But there is no limit to the number of thermodynamically adequate units of heat and work that may be devised; and, therefore, J may have any value for any given unit of work, and it may have any value for any given unit of heat. It is fixed only when both units are given. Supposing, then, that the foot-pound is the given unit of work, we may devise a heat unit such that J is unity. That heat unit we may call the foot-pound of heat. In the converse manner we may define, for instance, a B.t.u. of work.

In this fashion the First Law eliminates the need for a dual system of units for work and heat. We may, if we please, discard all of the old heat units defined in terms of prescribed fluid, unit of mass and temperature interval and retain only the usual work units. Such a step would remove the necessity for changing the value of J each time a presumably more precise measurement of work and heat comes to light, and it would simplify scientific literature by reducing the number of units commonly employed. Moreover, it would dispose of many units which have never been adequately defined. The term calorie, for instance, has been used to denote the zero Centigrade calorie, the fifteen degree calorie, the mean calorie between zero and 100 at atmospheric pressure, the mean saturated-liquid-enthalpy calorie between zero and 100 besides the one that was just the heat required to raise the temperature of a gram of water one degree without further fuss or feathers. It reminds one of the name Josh in the Billings family—there were "over six hundred of that name extant, besides a great many who has become extanted." But custom and the convenience of a unit which corresponds to unit rise in temperature of unit mass of water has hitherto saved the calorie and other heat units from the scrap heap.

They cannot be saved much longer. In 1929 the First International Steam Tables Conference in London adopted a definition of the calorie in terms of electrical work units, namely, *one calorie* equals 1/860 international watt hours*, which is evidently the definition of a calorie of work. There is, of course, a corresponding calorie of heat for which, with the calorie of work, J is unity. In current literature relating to the properties of steam this new calorie has completely supplanted the old ones of various definition. It is employed in the most recent German steam tables and the B.t.u. of the current American tables and of the British tables just published is defined in terms of it.

* It is termed an International Steam Table Calorie (or IT. cal.) for the present. With general acceptance the adjectives may be deleted.

With its adoption the mechanical equivalent of heat (or, rather, the electrical equivalent of heat) ceases to be a subject of experiment, because it is fixed by definition. This new fact prompted E. F. Mueller of the Bureau of Standards to ask the question, "what becomes of the numerous careful and elaborate determinations of this equivalent, and what is the probability that further measurements of this kind will be made?" And he answers, "The experiments now on record become a contribution to our knowledge of the heat capacity of water. . . ." Of course, he does not mean to imply that the celebrated experiments of Rumford, Davy, Mayer and Joule are to be dismissed as second-rate measurements of the properties of water. They were, indeed, the investigations that indicated the existence of a constant of proportionality relating heat and work in a cyclic process. They revealed to mankind a new truth, the First Law of Thermodynamics.

CONFERENCE ON ENGINEERING CURRICULA

University of New Hampshire

December 2, 1938

DEAN GEORGE W. CASE, *Chairman*

The conference dealt with the planning of engineering curricula. President Engelhardt in his welcoming address discussed how educators outside of our immediate ranks view practices in engineering education. The speakers from industry gave their views of certain phases of our topic as men who see our students in their senior year, immediately after graduation, during the period of their training courses and later as they pass up through the organization in the companies by which they are employed Certain trends in engineering education and the planning of engineering curricula were considered.

TRENDS IN EDUCATION

By FRED ENGELHARDT, President, University of New Hampshire

The growing volume of literature, the increase in circulation of educational and scientific journals treating of college and university problems, and in fact, the nature of the articles on the pages devoted to education in large city newspapers should be evidence enough to indicate the spread of a broad intelligent interest in education on levels beyond the secondary schools as now provided for the youth of America. This concern in what is being done in colleges and universities is not alone directed to what is called the liberal arts phase of college education but also to the technical, professional, and semi-professional types of schooling. Universities and colleges have been undergoing more marked changes during the past few years than during any period in the history of higher education in America. If viewed in contrast to the dynamic structure of a democratic society like ours, one readily accepts the challenge of those who view critically the education of American youth. If viewed in terms of a general appreciation of the increased interrelationship and inter-dependence of all knowledge and in terms of the need for increased coöperation among those who are masters of fields of learning to secure satisfactory solutions of modern social, economic, and political problems, then we must admit that

we have been slow in applying in our curricula a simple obvious principle.

It may be an exaggeration to state (and if this is true appropriate apologies are made in advance) that a review of current literature suggests that the educational units slowest to recognize in their work the dynamic nature of the economic, social, and political structure of our modern society and which generally speaking have been challenged the least by the need for fusion and synthesis in the educative process are the schools that have been responsible for technical education in engineering and in the sciences usually taught in colleges of technology and engineering.

It may not be unreasonable to assume that those educated in scientific procedures and trained to a factual approach to the solution of technical problems would have been the first to apply the scientific method to the educational programs designed for the preparation of men for leadership in technical and industrial life. Reviews of current educational procedures in many technical institutions of higher learning, however, appear to reveal thoroughly empiricalized processes of instruction paralleling the projection of the most advanced scientific theories. Experience, individual opinion, and tradition continue as significant determinants of curriculums, content of courses, and teaching methods, which have unconsciously directed the work to goals which produce well trained, precise, intellectual technicians who are not always educated men.

In this regard may I quote from the installation address of Dr. E. S. Burdell:

> I attach great importance to the education of our engineers without in the slightest degree deprecating the value of training. We have sent out battalions of trained engineers, but few have shown the capacity of manœuver beyond the confines of the drill ground. New strategies and tactics of labor, unexpected scarcities of raw materials and sudden elimination of markets often cast such men into a nostalgia for the good old days when 'labor knew its place' and raw materials were principally a free good to be exploited with no thought of conservation. Or, the bewilderment of the management engineer may lead him to follow a policy of crude expediency rather than insight in dealing with the individual worker, relying on the superficial rule that it is cheaper to fire a man than to try to understand the difficulties.
>
> If the engineers could be educated as well as trained, they would be much more likely to be able to cope with these ever-arising new situations. That is to say, if they could acquire wisdom as well as techniques, they would be that much more able to command a situation which threatens confusion, chaos, and defeat.

There are those who believe that the pitfall of narrow technical specialization may be avoided by introducing into the various engi-

neering curricula a course or two in economics, sociology, history or political science. One may well question whether the solution of the problem is so easily found. There seem to be as many solutions offered as there are individuals interested and I hesitate to join their number. It is, however, possible to suggest that certain of the technical courses now offered might be reorganized so that the approach and content would be that of the social science without destroying the technical viewpoint. The ends sought might thus be reached in a more satisfactory manner than by the above proposal. For example, a course in the history of chemistry or technology offered by one who understands the social, economic, and political implications of these fields of learning might be as acceptable, even to liberal arts students, as any orientation course now offered in social studies fields. The point I would stress is that opinions without factual foundation are of little value. In other words, is it not essential to the development of engineering and technical education that those responsible for teaching in these fields develop a philosophy of general education as well as a science of curriculum construction and teaching? Is there a need for teachers of engineering to study scientifically the problems of engineering teaching? Can it be possible that an educative process committed so specifically and so wholly to acquiring fundamental principles and exact knowledge may crush that individuality which needs time for the exploration of talent and interests and time for broadening experiences in a variety of fields before the young mind is set to the narrow way of a technical life? In the processes of education now established what provisions do we make for the creative mind other than to expect it to function after it has been molded to the pattern we set for all minds we are training for technical work?

These questions are not intended as criticisms of a field of education that has reason to be proud of its past achievements. They are presented merely as challenges and as suggestions of possible themes for discussion at this conference.

It is believed that much would be accomplished in engineering education if an assembly like this would encourage those among its associates who have an interest in the teaching problems related to engineering to devote their lives to this work. If there is a need for this work and if this institution can in any way contribute to projecting engineering education, it will be happy to do so. It might be desirable to experiment with this problem by establishing a trial institute for teachers of engineering in our summer school. If it is, we should like to coöperate with you in such ways as you may suggest.

* * *

WHY NEW TRENDS IN ENGINEERING EDUCATION?

By CHAS. F. SCOTT, Professor Emeritus, Yale University

New directions in which to go. Why go in new directions? What are the causes leading to new trends? Do they lie in a progressive urge by engineering educators or in the forces of changing external relations?

Development in engineering education is like that of the individual, there are three elements—heredity, environment, and will. Engineering education has a noble heritage of ideals and achievement, but grandfather methods produce only grandfather results.

Our environment—the world about us—is changing; *e.g.*, the science which engineers apply is expanding; modern industry is not that of the olden time which ridiculed the college man—now he is wanted for new functions. In its first quarter century the A. S. M. E. had only two or three presidents with college degrees; last year it had a college president and this year a professor.

Development of engineering education depends upon will and ability for adaptation to changing environment.

Has engineering the vision and the vitality to meet by its own voluntary action its expanding opportunities and the challenge to greater service?

An editorial in December *Mechanical Engineering* points out a major reaction; engineering has profoundly affected industrial and economic and social stability; but now, the industrial and economic and social confusion point to the engineer as the scapegoat, and they appeal to him to be their Moses to lead the way to the promised land. President Compton points out that the goals of present social and political aims—employment, shorter hours, new and more products to insure higher standards of living—all involve engineering. A new situation confronts us.

Let us note some aspects of "Engineering" and the influence of some elements in its environment.

The single engineering society and the four or five schools of four-score years ago have had a topsy growth. Societies have divided and subdivided along technical lines. Engineering curricula have promulgated diversity, as schools have grown as individuals, each free to fix entrance requirements, standards, and degrees.

Voluntary association of professors in S. P. E. E. has been the unifying, directing agency—but through acquiescence, not compulsion.

Engineering societies have not vitally concerned themselves with education. They have had papers—usually by professors,

and they have had student branches. Lately they have joined in E. C. P. D. with other groups. The conspicuous outcome of joint action is accrediting. In one sense, it is negative—the omission of the inadequate from the list; but positively it is a general stimulant and means for betterment—the first fine fruit of united action. E. C. P. D. also is advisory and not compulsory. Its great force lies in its quality. Joined with the schools and societies are the new State Registration Boards, stimulating through setting goals for attainment.

Thus engineering has a comprehensive and unique set-up, as its educational, professional and legal phases coöperate. The Medical Dean of Columbia has just recommended a somewhat similar assemblage of the several health elements in his profession.

Next let us consider some problems of environment.

1. Our students come from preparatory and high schools and junior colleges which have little engineering understanding or consciousness. Fortunately E. C. P. D. is concerned with the young engineer from choice to professional recognition. It is pioneering in the pre-freshman period to insure wise guidance, intelligent choice and discriminating admission.

2. Within the school are other departments—mathematics and physics, English and economics—which contribute bits of learning, which do not fit into a well rounded pattern. Administrators sometimes regard engineering as an amplified vocation. Faculties play checkers with the curriculum and professors cling to their venerable hobbies and forget the goal. Happily alert conferences are monopolizing S. P. E. E. conventions; the Middle Atlantic section has a dozen on its program at New York University next week.

3. Student life—its ideals, its tone, its type—puts its stamp upon the graduate. A professor recently remarked that we are realizing that the education of the student is a twenty-four hour process and that vital qualities are extra-curricular. "Intelligence is not enough" proclaims Dr. Cowley, new president of Hamilton College, in his opposition to the Hutchins philosophy. (*Journal of Higher Education,* Dec. '38.) The residential college scheme at Harvard and Yale—a revival of ancient customs—is one method of unifying student life.

4. Industry makes new demands. Technical design and the like are not enough, it wants men for research, for administrative and executive and business positions calling for scientific attainment and for personal qualities.

5. Advancing science shifts the scene. A dean seeking a head for electrical work was told of a man unique as a teacher and with rare appreciation of the needs in industry and utilities. He commented that the engineers of tomorrow will apply the new science

in new fields, and asked whether endowed institutions should not prepare him for new tasks.

6. Industrial research grows in extent and in results. In some practical developments our four-year graduate with experience which gives appreciation of needs and operating conditions can get useful results where the theoretical Ph.D. cannot. We really need a new type of Ph.D. with engineering attitudes to apply new science to new engineering for new industry.

7. In management new elements of personal quality and attitude and training are stressed—these and similar situations in and outside of industry raise the fundamental problem of general vs. special training. Notable among these is the "Professional Engineer" certified by Registration Boards. Engineering procedure has fewer years in school and depends more on subsequent experience than other professions. Hence the importance of the foundation laid in school and the character of employment and experience. Employers should be trainers.

Engineering education has by many of us been looked upon as a type of education utilizing applied science as a preparation for many careers—among them technical and professional engineering. Opposed to this is the idea that some phase of practice is the goal of the curriculum. Is it to be—education via the scientific, engineering route, or specific engineering via the educational ladder? How far can we justify the first? Must we recognize that there are too many kinds of engineers to be cast in one mould, or can we make our mould basic—an adequate foundation for all? After all, what is the scope of engineering—What are its limits? President Harvey Davis of Stevens and A. S. M. E. stresses more fundamental scientific background, also management—the ability to get things done through organization.

8. The paradox of social progress rises as a spectre—more technology and production are essential for employment and for better standards of living, yet they threaten to increase social confusion. Is this Frankenstein episode a challenge to the engineering educator? President Doherty accepts it and proposes "a planned education supported by both technological and social research"; and he is doing something about it.

Freedom of initiative has enabled experimentation in engineering education. That may continue our route of progress. Fortunately our accrediting is not regimentation.

In summation, the fruits of engineering achievement create a new environment, a new order of life with its new problems for the engineer; the significant present trend is toward a new professional consciousness to which registration is making a distinct con-

tribution; toward a realization that industry must train as well as use men; toward the realization that the Development of the Young Engineer spans the years from high school choice to professional recognition and is a joint responsibility of the Schools, the Professional Societies and the Registration Boards—a Triumvirate with unbounded possibilities.

* * *

TRENDS IN ENGINEERING EDUCATION

By FLOYD P. BROWN, Westinghouse E. & M. Co.

To members of this conference, an historical treatise discussing trends in engineering education will probably be supplementary information. It is not the past but the present and the future that give the challenge to education. All engineering analysis, however, is based on certain known conditions. Hence, to maintain logical sequence this paper is intended to trace the path of engineering curricula in its progress through the years.

The writer, a recent graduate, is interested in the problems facing young men entering industry from technical institutions, and presents the following review of curriculum trends not as new material but as a summary of published reports from authoritative sources. The historical data have been abstracted from Bulletins No. 10 and 11 of the Investigation of Engineering Education as published by the Society for the Promotion of Engineering Education, Vol. I, pages 454–554. The discussion of recent trends and curriculum standards is the result of study of college catalogs and contemporary papers on engineering curricula.

The engineering curricula of 1870 were obviously derived from collegiate models as variants to the then existing science and language curricula with modifications to include a bit more of practical material.

The years from 1870 to 1885 were the formative epoch in American engineering education. The collegiate type of curriculum, with its extended base of science, mathematics, language, and social studies, though modified by the presence of expending engineering knowledge and technique, proved its stability and became firmly established as the basic process in engineering education.

In the period from 1885 to 1900, American engineering education came into its own. Great industrial expansion and notable progress in invention caught the popular imagination. Education in applied science grew in popularity to a point where it seemed to threaten not merely the preëminence but even the actual existence of classical culture for young men.

The first decade of the twentieth century saw engineering education in America reach the climax of its popularity relative to other major divisions in higher education. As the second decade developed, agricultural education sprang into prominence; and as it closed, collegiate education for business was in a rapid upswing.

These developments somewhat checked the expansion of engineering education. The prominent place gained by engineers in the management of industry, the notable contributions of engineering to the techniques of production, and the conspicuous place taken by engineers in war activities led to a marked increase of emphasis on the administrative and economic side of engineering.

The influence of this march of events on engineering curricula is still apparent. Distinct curricula to emphasize the administrative rather than the technical aspects of engineering were introduced rather widely. The place given to economics in all curricula was augmented, often at the expense of time given previously to other social subjects. Business electives in engineering curricula were more widely provided. In the years from 1918 to 1924 there was a discernible trend away from the specialization of undergraduates.

The effort to stretch a four-year college program into either an expansive or an intensive training was frankly abandoned, with a reaction toward simplification of programs and a greater emphasis on general training.

In the past twelve years there has been an accelerating tendency on the part of curriculum makers to lessen the number of pure engineering subjects. Many courses in curricula have been simplified to correlate the fundamental theory with the practical applications.

The most notable changes in engineering curricula in the past 15 years have been the addition of (*a*) more semester hours in the physical sciences, namely chemistry and physics, (*b*) prescribed courses in economics and business, and (*c*) provision for a greater number of elective hours both technical and non-technical.

The growth in the physical sciences has been at the expense of the foreign languages, which have been completely eliminated as required courses in many curricula. The growth in the business courses and electives has been at the expense of the graphics courses, the shop courses, and those in the major technical field.

This growth has been possible because of simplification of the graphics and shop courses—condensation and concentration of work hours helping to hold the quality and quantity of work without loss to the student. Many courses in the major technical field have been shifted to technical electives to allow a small degree of specialization, usually done in the senior year.

The following paragraphs taken from a paper by A. A. Potter, Dean of Engineering at Purdue University, published in the *Armour Engineer*, are so pertinent to this discussion that they might well be considered as additional evidences:

Engineering of a century ago was mainly an art. Thus engineering colleges during the earlier years of their existence stressed manual dexterity; they were concerned more with training for the acquirement of skill rather than with education in basic principles; they placed major emphasis upon studies which led to usefulness immediately after graduation and not upon general education values.

Developments in transportation, mechanical power, communication, illumination, chemical technology, mining, metallurgy, and other new industries and public utilities have resulted in a demand for special educational preparation. Engineering colleges attempted to meet these new requirements by setting up numerous specialized engineering curricula.

During the past thirty years there has been a definite trend away from the purely utilitarian and specialized in engineering education. The engineering colleges have given up the idea of trying to train in a four-year undergraduate curriculum specialists for the various fields of application. The best of these institutions have been tightening up their entrance requirements, and have been concentrating upon subjects which are basic and which the student has difficulty in acquiring by his own efforts.

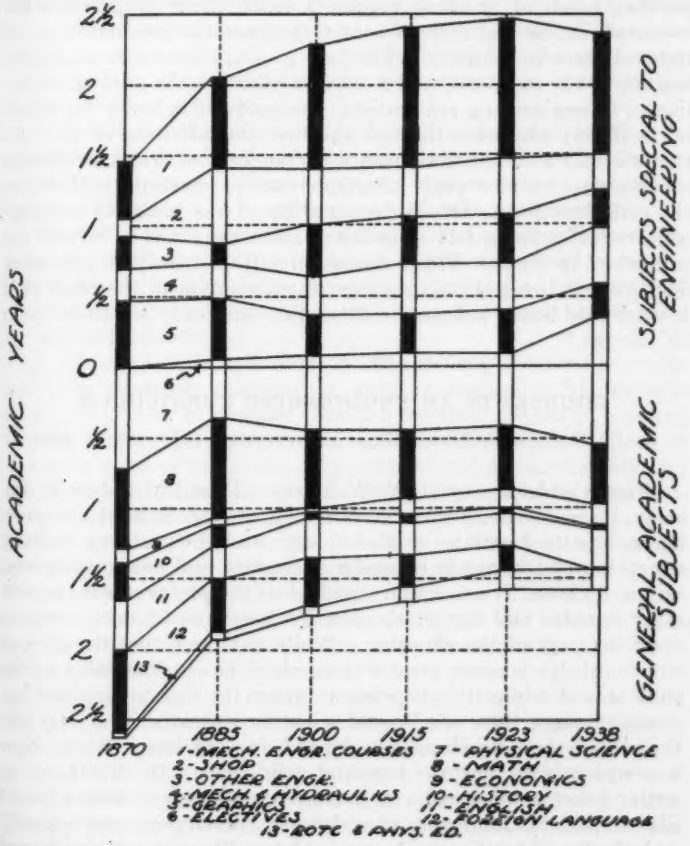
While the scope and range of the engineering field have been constantly broadening, increased emphasis is now being placed by engineering teachers upon fundamentals; completeness of detail is being subordinated to thoroughness. The providing of a background of engineering knowledge is not being considered so important as development of ability to reason logically and to arrive at truth by observation and analysis.

The time given to informational courses is being greatly reduced, and an effort is being made to awaken the creative instinct of the student and to stimulate independence of thought and action and self-reliance. Specialization is being definitely discouraged for undergraduates, but is given a place in connection with research in the graduate programs of study which lead to the higher degrees.

Contrary to the general impression, undergraduate engineering instruction is not purely technical but has been planned so that the undergraduate student devotes about one-half of his time to science, mathematics, and the humanities. Nearly all undergraduate engineering curricula include required courses in English, history, and economics.

In a number of engineering colleges the undergraduate program of study permits electives in psychology, sociology, accounting, personnel administration, business law, banking, corporation finance, and other courses which are helpful to the student in acquiring an understanding of social and economic problems. To an increasing extent engineering students are receiving instruction in industrial engineering and management. It is the general opinion, however, that extended business training should not take place in an engineering curriculum of basic instruction in science and technology.

The following chart shows graphically the trend in mechanical engineering curricula from the year 1870 to 1938. It may be seen



that in the period of sixty-eight years shown on this chart there has been a transition to include much more work in subjects special to mechanical engineering thus reducing the number of hours and courses in general academic subjects.

This chart projected from 1923, the date of the Wickenden Report, to 1938 by study of the catalogs of representative engineering institutions, also discloses the near elimination of two heretofore requisite subjects, history and foreign language.

In summarizing this study and Dean Potter's comments, the following signposts of progress point the way to further evolu-

tionary changes in engineering curricula. A new situation has arisen in the relationship between colleges and industry. The expanding needs of industry require a much closer coöperation between education and management to prepare the graduate for his rightful place in industry. The past 15 years have seen a smoothing out of the curricula, and a definite effort on the part of education to fit engineering graduates to the needs of industry by allowing a liberal education through the first three-fourths of the curriculum and a concentration on a chosen field of endeavor during the fourth or senior year. Fundamentally, curricula still follow the collegiate form; but the recognition of the needs of industry are gradually being felt as industry takes the steps to inform the colleges of its needs. This coöperation will do more than any other one thing to bring the slower moving curriculum to the place that it must hold beside industry. Education has really begun to "step on the gas."

* * *

COURSES IN AN ENGINEERING CURRICULUM

By PAUL CLOKE, Dean, College of Technology, University of Maine

Recent addresses by L. W. W. Morrow, President Robert E. Doherty, Carnegie Institute of Technology, President Karl Compton, Massachusetts Institute of Technology, and some others, indicate something of the trends in modern scientific and engineering education. Viewed from certain standpoints the problem looks exceedingly complex and one which calls for longer and longer curricula upon the part of the educator. While it is true that the store of our knowledge is much greater than when the speaker was a college student and while it is hopeless to know the day to day developments in more than one line of scientific endeavor, it is also true that all of these developments depend, in very large degree, upon a comparatively few fundamental principles. To illustrate, the writer never studied radio as it is known today, yet with a knowledge of the fundamentals of resistance, inductance, and capacity, and the laws of radiation he was able readily to master and teach the important parts of this subject. The same thing was true of illumination and the tungsten lamp, the same thing could be true of the new luminescent lamps. The point that I am making is that the engineer is trained in the scientific attitude and consequently approaches any new problem from that viewpoint.

In a democracy free thought, inventive genius, and initiative have ample scope for development. This condition of affairs together with great natural resources account for the great industrial expansion and educational advancement of the United States.

Equal opportunity for all is, of course, our slogan, yet we know that there are the widest differences in individual abilities and capacity for achievement. This fact and the principles of democracy are in entire accord, indeed, the development of those individuals who are capable of leading is essential to the continuance of democracy. This is the problem; it is our concern as to how this end may be best achieved.

This plan of higher education is well exemplified by that instituted at the University of Virginia many years ago by Thomas Jefferson. He emphasized the necessity of discovering and developing those students who would become leaders in a democracy.

It is folly to suppose that a series of accumulated facts, ideas, principles, or theories will of themselves give an individual power. It is the coördination and integration of knowledge together with personality and the ability to use coördinated knowledge that gives an individual power.

In my opinion there is room for marked improvement in teaching by more closely coördinating existing courses, rather than to allow each teacher to consider himself a law unto himself in teaching what he will in just the way he wishes. Each teacher must, of course, be allowed to use his own methods and accomplish his own ends, but each course can and should relate to others in the students' curriculum. This is true in a very concrete way in professional courses, as for example, in courses in electrical engineering. By tying succeeding courses to those immediately preceding the student gets a concept of a coördinated whole. That such a procedure results in increased efficiency is almost self evident. The same procedure is entirely possible in such courses as economics, history, philosophy, or psychology.

The latter statement has far deeper significance, however, than merely coördination of courses of like kind. The student should be shown the interrelation of history, economics, and psychology to science and engineering and how they are all interdependent and how they have influenced each other through long periods of time. We can thus show the student why and how he must consider the economic, historical, and social relationships and the human factors in industry to be of paramount importance along with his professional engineering studies.

For example, in the teaching of electrical engineering to non-electrical engineering students, as civil and mining engineers, the instructor in electrical engineering feels that it is incumbent upon him practically to teach the design of the magnetic circuit. The result is that such courses have come into serious disrepute and in some instances the head of the department in civil or mining or other non-electrical curricula has simply eliminated such courses

altogether. I am bold enough to say that what such students need and want is a knowledge of the fundamental action of direct and alternating current motors and generators, together with a sound analysis of the economics of any given power and energy situation. The plain fact is that the genesis of the situation goes far deeper involving the historical and humanistic relationships involved. That is the reason why it is so desirable that an instructor in engineering should have had worth while industrial experience and first hand contact with the problems of labor. It is not difficult for the well trained and wide-awake instructor to work in enough of this material to make the attempt worth while and be an inspiration to the student who will continue the study far into the future.

At the present time there is no doubt that much waste material is being taught. For example, today hydraulics and mechanics have assumed new aspects. This calls for new methods and new presentations; not giving the old matter in the same old way and adding the new if the instructor happens to know what it is. This is, however, not the most serious aspect of the present situation. As each new instructor takes charge of a student he makes no attempt to integrate the student's present knowledge but assumes that he himself must start from scratch. This overlapping of courses is an economic waste, insofar as efficiency of the educational process is concerned. Previous knowledge can readily be related as the work progresses or as new problems arise. I know because I have successfully worked out this very plan.

Leave something for the future—it is not necessary to teach all of present knowledge or applications. The teachers must work out a coördinated plan of how much to teach so that the various courses will dovetail into one another in such a way that the student will realize almost unconsciously the objective sought. In such a case something is left for the student to work out for himself in the future, in fact as long as life shall last.

There is only one way to achieve the advantages of the plan described above and that is for the administrative officers gradually to educate the faculty to its manifest advantages. This will not be achieved in any short interval of time nor without give and take on both sides and without compromise. One of the most serious obstacles to the development of these ideas is the apathy of the instructing staff toward them, especially the older members. Instructors, in general, have not come to realize the demand on the part of industrialists for men trained in the broader aspects of engineering that we have been discussing. The advantages to be gained are, however, worth all the effort one might exert not only from the standpoint of more worthwhile education but also from the standpoint of the individual in orienting him into the engineering

profession and in needed cases, what is equally important, orienting him out of it; thus saving those tragedies of the late twenties and early thirties.

To summarize, first: It is possible to coördinate, interrelate, and integrate, to a greater degree than is now being done not only the various courses in a given department but the courses in a given curriculum.

Second: It is possible to economize to a greater degree than is now being done on the time being spent on any given course by not attempting to teach so much but to leave considerable for the student to develop himself as the years go by or at least at a later time. More emphasis is desirable on the fundamental principles involved.

Third: Increased knowledge is desirable regarding the relationship of economic and social laws and the laws of human reactions and historical facts to engineering.

Discussion

G. F. Eckhard, Vermont: Are comprehensive examinations now given at Maine?

Dean Cloke: Two-day comprehensive examinations carefully prepared by the faculty are given at the end of the sophomore year. At the end of the senior year a two-day written examination on professional courses is given, followed by a one to two hour oral examination by members of the department.

J. A. Bullard, Vermont: Has there been an apparent improvement in interest by the students since the comprehensive examinations were started?

Dean Cloke: Greater interest is evident, but the main purpose of the plan is to determine whether the men really are qualified to be engineers. I would also give an affirmative reply to Dean Edel's question as to whether there is room for improvement in integrating courses by the faculty.

* * *

NON-TECHNICAL ASPECTS OF ENGINEERING

By OVID W. ESHBACH, American Tel. & Tel. Co.

Education—from the general viewpoint of one engaged in industrial employment our concern is primarily with personal quality and secondarily with the details of educational background. On the other hand I do not want to be misunderstood or create the impression that we do not consider the details of a graduate's education because we very definitely do. Not only is his special

training taken into consideration but anything in the way of other experience that is of value in appraising his qualifications for and interest in a particular job with us.

Some time ago I was amused by an advertising slogan "It takes two million opinions to make a fact." If you are willing to accept this in part, I will venture my opinion that you are not primarily training students for industry but rather educating them for life, in which industry is one of their major environments. That is, the responsibility is to the boy not to us. His educational career like his industrial experience is continuing and the former only begins in college. In my opinion we are not expecting a complete education but rather an alertness to change and an active expectation of continued preparation to meet new situations.

If this is anywhere near accurate the non-technical aspects of engineering education may not be overlooked. Time adequate to meet a predetermined educational objective should be provided. How much, is for you to determine, also, what is most important, the objective. If what I say may be construed as a criticism of what is being done, I should like that criticism to be directed at the lack of cultural objective commonly present in the uncoördinated studies now provided for as an excuse for cultural content.

There is a universal principle of education, also training, which recognizes that the most effective time to impart knowledge or skill is at or just before it is needed. The adding of courses too often results merely in the acquisition of knowledge that lacks stimulation because of the remoteness of its application which comes in the more mature experiences of life. This latter treatment or method may well be characterized by the phrase "cold storage education." If the emphasis could be shifted to the cultivation of a way of thinking and the development of the desire to understand and synthesize principles which have crystallized from sociological and economic experience, students would be more sensitive to the forces of change and more eager to pursue and enjoy an intellectual life.

I realize that the important and perhaps impractical thing is the selection of teachers of arts subjects who appreciate literature, history and economics as professional fields but at the same time are willing to sift from the mass of material those things which have and are still likely to control social thinking. The utilitarian characteristic of engineering educational discipline also presents a psychological obstacle that must be recognized and receive sympathetic treatment. A human tendency toward passive tolerance needs to be replaced by active intellectual challenge. Naturally, the objectives of instruction in economics are different when considered from the viewpoint of professionals in this field. The an-

swer should not be for engineers to teach economics but for economists to teach it with special consideration for interest and the possible usefulness of further study as required in the later life experience of technical graduates. Engineering economy is a different thing and is a technical subject that belongs in the school of engineering.

Cultural education implies the ability to learn from social experience and to control social experiences. Extra curricular activities should afford some possibility of contributing to cultural education. A good example of the cultural values possible in a planned activities program is the Boy Scout program. I have never seen a senior engineer and Eagle Scout whom I did not feel would fit into our business. He is the product of a planned program based on active participation and the psychology of success and reward rather than failure and punishment. I was told by one of our G-men that he had never seen a finger print record of a Boy Scout in the criminal files. If their system is only partly responsible for such achievement it is worthy of study in planning objectiveness in college extra-curricular affairs.

There is still one other subject that is associated with the thought of liberalized education—the matter of free selection. I would not worry about it in the case of good and mature students but wherever the selection is prompted by a limited or narrow experience, it seems to me there is a responsibility for guidance. He should be made to realize the direction he is going, the distance to the objective if clearly defined and the consequences of his decision. Otherwise he may make his selection on superficial judgment that will later impose too great a burden in the effort of correction.

In closing I would like to emphasize again the continuing function of learning in a cumulatively effective life. The experiences of life can not be wrapped up in packets and transported to a college atmosphere except in limited cases. All life is a matter of adjustment to meet changing outlooks of future experience. Selection of college studies is the first guess in attempting to plan for a life experience that shows periodic points of concentration and deviation. Training for an indefinite future experience is not as futile a venture as would seem, either in engineering or arts for in both there are definite objectives applicable to the college period of life but we need to guard against the pressure of apparent expediency to meet the forces of a changing industrial and social environment.

Discussion

R. L. Wales, Rhode Island State College: Engineering education should be recognized as being a two-stage process. The first,

or non-specialized stage, can best be carried out in college, and specialization can best take place after the completion of the college course. Considering this conception to be correct, an important consideration by educators which should receive increasing attention is the development and maintenance of interest by a student in work he does in college. A salary usually furnishes this incentive for interest after graduation.

F. W. Roys, Worcester Polytechnic Institute: Can mathematics and physics be handled in such a way as to stimulate interest?

Dr. Scott: The problem usually is not how to stimulate, but how not to kill interest.

H. P. Burden, Tufts College: The interest of a student in a particular course is likely to depend, to a considerable extent, upon his aptitude and preparation for the subject matter of the course.

Dr. Scott: Should not the judgment of a young engineer's qualifications by a state licensing board be based on promise rather than the present state of his experience?

O. W. Eshbach: Yes. In college the greatest stress should be placed upon the development of a way of thinking and not upon the imparting of special knowledge. A student receiving such instruction should be sensitive to the changing field after graduation. It is difficult to determine by tests whether the young engineer possesses this quality.

* * *

LABOR RELATION IN INDUSTRY

By M. M. BORING, General Electric Company

The problem before us at the moment seems to be "Should we attempt to introduce into the engineering curriculum material to enlighten the engineering student on some of the fundamentals of labor relationships?"

It appears that under ideal circumstances such material might be introduced to advantage but great caution and study must be made before organizing courses in labor problems.

Probably five per cent or less of all engineering graduates will ever have positions that involve direct contact with labor and labor problems. If this figure is correct, it is probably unwise to consider that courses in labor problems will have a direct effect on the future of the average engineering graduate.

The new courses in industrial, administrative, general, and similar engineering are supplying large numbers of men with training for work that will involve labor contacts, and a survey of the graduates of one of the industrial engineering courses that has

graduated a large number of men indicates that although many do follow work involving labor relationships many graduates of this course eventually end up in sales and other work which has no real contact with labor problems.

It must be conceded that in order to introduce the proposed subject other things must be dropped. This in all probability will be the deciding factor regarding the introduction of this subject. We seem to be spreading our material so far that there is a tendency to get further and further away from fundamentals. Is it not time to call a halt and make a complete study of the curriculum rather than to "just introduce another course."

Again, who would teach such courses? In order effectively to send the student out with a good understanding of labor relationships, we should see that he had an all-around unbiased picture. This would involve presentation of material from the viewpoint of both industry and labor, and it is doubtful if such a presentation can be effective unless made by people on both sides who are actively engaged in industry. To present this important subject from the viewpoint of the typical economist might be misleading. The theory of labor relations is so intangible and dependent on local conditions that unless great care is taken, students may get ideas that will confuse rather than help.

It is my impression after giving this matter much thought that the only feasible way of presenting this subject is by an occasional lecture by visiting engineers, administrators, and labor officials, and even then the real value of introducing the engineering student to the complex subject of labor relationships is questionable.

Discussion

W. H. Kenerson, Brown University: I would like to ask whether Mr. Boring would recommend the inclusion of psychology?

Mr. Boring: It probably would be better to double the amount of physics and leave psychology until later. It is better for us to build a tree trunk well and let the branches grow where they will.

W. L. Edel, Connecticut State College: Connecticut State College has just revised its curricula in civil, electrical, and mechanical engineering, all of which had to be approved by the faculty of the whole College. These three new curricula, as approved, require a total of 140 credits for graduation and include, each, approximately twelve credits of free electives.

The faculty discussion, before approval of these curricula, centered around the non-inclusion of psychology with the required social sciences. Some of the non-engineering members of the

faculty objected to the dropping of psychology and thought that this subject should be included with the social science requirements in all curricula. Most of the faculty objection dealt with the small number of credits of free electives available to engineering students, claiming that an engineering student had no opportunity under such conditions to get a liberal education.

S. W. Dudley, Yale University: The important thing is not whether psychology should be taught, but whether a teacher can be found to handle the subject properly, particularly if it is introduced in the first year.

Mr. Boring: The important thing is the frame of mind in which the student leaves a course.

Dr. Scott: The right teacher is a more important factor than the name of the course.

Mr. Eshbach: The objective of an Economics or Sociology course, as set by the engineering school will usually differ from that set by the Arts teacher of such a course.

Mr. Evans: When such a course is included in an engineering curriculum, the engineering faculty usually fails to state the objective definitely.

J. H. Belknap, Westinghouse E. & M. Company: Dean Case has asked that I discuss in some detail the plan followed by Westinghouse in the selection and training of engineering graduates for technical positions within the company.

Our predicted needs are the basic guide for the selections, and the number of engineering graduates chosen for the Graduate Student Course is a reflection of our estimate of the technical positions available at the end of training.

Interviews, usually conducted on the college campus, identify the inclinations of the students, and numerous consultations after the graduate student begins his experience with us confirm or disprove the correctness of the training schedules established for the particular individual. A large part of the training is association with the various types of employment offered. This association is not only through shop and office experiences but from class room and other contacts with leaders in the various operations within the company.

The graduate student is encouraged to elect his own field, but it is not expected that he could do so intelligently until he has had some view of that activity and other company operations. Guidance is offered but the final choice of work is the decision of the graduate student. It is our belief that the technical graduate can better serve the company if he is totally satisfied with his work. It must be admitted that he will make better progress and will

advance in his position with the company if he pursues employment in the field of his own choice.

Positions in the field of metallurgy, physics, and chemistry are usually filled by those who have elected such courses in college. The choice of such an academic pursuit is usually the result of some particular bent, and in many instances the candidate under consideration knows very definitely just what he would prefer to do. For obvious reasons, the man who has attained to an advance degree is most often chosen for such positions.

Many of those going into mechanical engineering and electrical engineering positions in the company are in need of thoughtful guidance. The proper candidate for a commercial position may not know of the high plane in which the commercial engineer operates and, for that reason, may not have given selling serious consideration. Likewise, the technically well equipped graduate may have thought only of research, while in reality his interest is centered around design and application problems. Often-times the candidate is found to have a totally incorrect idea as to the activity of the engineers who have to do with apparatus or circuit design problems.

After a period of orientation, many of the interests of the candidate are clarified. Then a friendly and searching conference with the graduate student often reveals the real desire of the young man. Subsequent assignments prove or disprove the correctness of the plan established for his final training and eventual transfer to a salaried position.

Classroom work or formal training parallels shop and office assignments and is divided into general training school for commercial and works management candidates and engineering school for both electrical engineers and mechanical engineers who prefer technical engineering positions. Graduate students trained in physics, chemistry, metallurgy, and similar lines enter one or the other of the two schools, depending on their eventual likely positions and the sufficiency of their academic training for the technical work undertaken in the two schools. Mechanical design and electrical design schools follow engineering school and are for those who should receive more advanced training than that given in engineering school. The graduate student training program usually accomplishes the placement of candidates in technical positions within the company after seven or eight months of training assignments.

Westinghouse finds young college graduates eminently well qualified, after orienting and training, for the positions which they are to undertake as junior employees. Students who have developed

properly their analytical abilities in college and who have had the proper fundamental training in the basic sciences and mathematics can be expected to render good service, attain to excellent positions and have complete enjoyment in their work if placed in the field of their particular interests.

From our experience of last year, the procedures outlined above resulted in the placement of 180 graduate students in technical positions within the company. It is of interest to note that of this number but nine transferred to other activities as orienting reached its final stages. These changes were such as from sales to engineering or vice versa and from engineering or sales to works management.

C. S. Ell, Northeastern University: Do all graduates enter the same exploratory courses on taking positions with the Company?

Mr. Belknap: No. There are two separate schools; one for commercial or works management candidates, and certain specialty type employments, and another for those who are to undertake engineering positions in the fields of design, application or research.

Dean Cloke: Is it possible for a man to transfer from one school to the other?

Mr. Belknap: Yes. While it is not desirable to transfer after a large part of the work in either school has been completed, the graduate student can even then choose a different field of work and later, in a subsequent school, follow the different course to completion.

H. P. Hammond, Pennsylvania State College: Engineering curricula are such as to prepare chiefly for design rather than supervision; whereas many of our graduates find positions in the operating functions of industry. How may our programs be altered so as to make them more adaptable to this side of industrial practice?

Mr. Belknap: The engineering curricula of the country are apparently well suited to the requirements. However, I would like to stress the point that Mathematics and the fundamental sciences are of the greatest importance in the academic training of candidates for technical positions.

I might take this opportunity to say that it would be beneficial to acquaint engineering students in the junior and senior years with the various opportunities offered by industry. Preliminary guidance of this kind would be most helpful. The curricula need not be changed or added to to accomplish this purpose, since the use of the seminar, meetings of the student branches of the technical societies and occasional conferences with the leaders of industry would be sufficient.

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DESIGN OF AN ENGINEERING CURRICULUM

By H. P. HAMMOND, Dean, The Pennsylvania State College

The E. C. P. D. Committee has opposed any action which would tend to cause rigid standardization of engineering education, and hence has avoided laying down any detailed specifications for curricula. However, it became necessary to prepare a statement that would answer numerous questions as to how, in general, the acceptibility of any curriculum as a professional program of work in engineering might be judged. The Committee's statement was one of general principles and specified broad divisions of subject matter rather than detailed quantitative requirements in specific courses. Four such divisions of subject matter are deemed essential:

(1) Those physical and mathematical sciences that are basic to the division of engineering under consideration.

(2) The principal divisions of pure and applied mechanics relevant to the field of the curriculum.

(3) A group or groups of courses of professional engineering content in the particular field of the curriculum, as well as such other engineering subjects in related divisions of engineering as are essential to a broad knowledge of the field of practice in question.

(4) Subjects of generally humanistic or cultural nature.

The Committee believes that the treatment of the major subjects of every engineering curriculum, whether in basic sciences, mechanics, or professional subjects, should be quantitative and analytical in nature and not essentially descriptive or imitative or purely manual. Every curriculum to be worthy of professional recognition should also include sufficient work in design, or the creative phase of engineering, as related to machines, structures, systems or methods. The element of economy and costs should be included. Finally, there should be an essential relationship between work in science and mechanics on the one hand and the professional courses of the curriculum on the other.

I have prepared a sample curriculum in civil engineering. It has the following characteristics: a total of 136 credits required for graduation exclusive of physical and military training; never more than six, and usually not more than five courses required in any one semester; one required or elective cultural study in every semester and required thesis throughout the senior year.

Discussion

Professor Roys: Referring to your sample curriculum, Dean Hammond, would thermodynamics be considered a part of physical science?

Dean Hammond: No. Only the formal courses in physics.

W. C. White, Northeastern University: Should five be the upper limit of the number of courses to be taken in one semester?

Dean Hammond: Yes. Possibly four. I agree with Deans Edel and Cloke that advanced R.O.T.C. should be placed among the non-technical electives.

Dean Ell: I would like to get Dean Hammond's opinion on whether the inclusion of the thesis should be left to the discretion of the faculty or not.

Dean Hammond: I feel that thesis should be required. In one institution with which I have been connected there has been a long and arduous struggle to bring thesis to its present satisfactory state. The faculty feels that it gives needed opportunity for the student to do individual work.

Dean Edel: In building our new curricula we found it possible by careful arrangement to make the requirements of the first two years uniform for all engineering students. The main object being that it is hoped sometime soon to introduce special examinations to determine which of the students should be allowed to continue with their engineering courses in the junior and senior years, and also to delay the selection of the branch of engineering in which the student is to major until the end of the sophomore year.

At present the engineering students at Connecticut present their theses in classes run by the students as professional society meetings. This method has proved highly successful in every respect. Listening in at these discussions one is convinced that engineering courses are necessary for the proper understanding of the engineering concept of applied science.

Dean Case: Will Dean Garran give us his experience at Dartmouth with a liberal curriculum preceding the engineering program?

F. W. Garran, Dartmouth College: The plan works very well. We find that non-professional work can best be given in the early years before the student's interest in the professional courses causes him to slight the humanistic studies necessary for a well rounded college training.

H. M. Westergaard, Harvard University: We find it desirable to give the student more freedom rather than less to construct his own curriculum. He will do so with guidance by the faculty. The sense of responsibility that goes with this freedom contributes toward the student's interest in his work.

Dean Dudley: We seem often to plan our programs of study and set requirements to meet what we assume to be the needs of the "average" student. But the student is always an individual, not one of a group of comparable units. He does not fit any aver-

age. Consequently we are usually modifying, adjusting, and adorning the curriculum in the hope of interesting, arousing, and stimulating the mediocre student. The gifted student may be left to shift for himself, which he is probably capable of doing fairly well. B's and A's would be his portion, no doubt. His performance is bound to reflect his superior endowments, but how much more substantial and satisfying might be his intellectual progress, if he were given special opportunities commensurate with his special aptitudes and abilities!

With large classes and crowded schedules this is not easily accomplished. Much depends upon the facilities and range of opportunities presented by staff and equipment in the particular school. At Yale we include in our announcement of undergraduate engineering courses of study the following paragraph:

"Each department of study is authorized to make such special provision as it considers appropriate and finds practicable for those students who show exceptional ability and promise. The department concerned may assign them special work, admit them to advanced courses, or provide opportunities for research work. This will be feasible mainly in the Senior year, when the necessary fundamentals, such as mathematics, etc., have been mastered. It will enable such students to make more rapid progress in their chosen fields in proportion to their superior powers."

Not many students respond to this suggestion. Some select advanced courses in their particular field of interest. A few elect a special laboratory problem for experimental study. In some departments there is a tendency on the part of two or three students each year to plan a five-year instead of the normal four-year program leading to the Bachelor's degree. Usually the extra time thus afforded is utilized for non-technical electives, sometimes for a wider range of background courses.

I heartily agree with Dean Westergaard's emphasis upon the advantages to the able student of some freedom of choice. His interest is quickened and intensified and he develops initiative, self reliance, and a sense of responsibility—all important elements of growth in intellectual capacity.

Dean Case: When we were discussing non-technical courses Professor Evans spoke of the failure, generally, of the engineering faculty to state definitely the objective of a course. Would you say, Professor Evans, that there is a similar failure connected with the design of an engineering curriculum?

Professor Evans: Building a curriculum by stating the component courses leaves the problem in about the same state as the design of a machine or structure would be left if the design stopped with the selection of the materials to be used. In the design of an

engineering curriculum as in any structural design, the functional consideration is probably the most important feature.

Too little consideration has been given the student in most discussions of this sort. He is usually about eighteen years old, fairly well prepared for college work and has a rather definite idea that he wants a technical training in order that he may earn a better living. This is the material with which we must work to turn out an engineer.

It may be well to define the term "engineer" as used here. I believe we may say that the young engineering graduate is one who has been thoroughly trained in the basic sciences and who has had sufficient practice and guidance in their application to simple engineering problems to give him confidence to attack larger problems. Our present curricula do a fairly good job of molding the young man to fulfill the above specification but improvement is possible.

The first two years should be taken up by the basic sciences with an introduction to the major subject in the sophomore year. During the last two years, in general, no elementary courses should be given. The work should take a logical course in applying the basic sciences to the solution of engineering problems. Carrying problems through from conception to completion gives the student a feeling of confidence and a sense of making progress. Free change from one branch of engineering to another frequently observed following graduation suggests that it is the application of the basic principles which is of major importance rather than the special field in which the work is done.

Forty or fifty years ago, such engineering work as was included in the curriculum was covered thoroughly and painstakingly. The tendency since then has been to inject one course after another in an attempt to keep up with the times until little in the curriculum can be covered thoroughly. Subject matter has been placed ahead of purpose and the ultimate objective, creation of a state of mind, is not attained.

Ten or twenty years after graduation engineers may be required to do administrative work but in the vast majority of cases they are hired to do specific jobs along the line of their major work in college. In exceptional cases, the employer may recognize in the young engineer outstanding administrative ability and recommend post graduate work. For the run of the mill, though, the time between graduation and assumption of administrative duties is so great that the wisdom of including administration courses in the undergraduate curriculum is doubtful.

In cases where engineering graduates are chosen for non-engineering positions the employer knows that the engineer is most often

successful. The employer looks for personality and the engineering type of mind and then gives suitable additional training. One of Dr. Compton's investigations showed that the engineering graduate stood a thirty to one chance over the man with a B.A. degree of getting into administrative work.

Just how far we can broaden the present curriculum and still have the resulting product an engineer, I do not know. There is good evidence that the present four year curriculum can establish the desired technical attitude. Let us not change it without due caution.

A. E. Winslow, Norwich University: I think we will all agree that there is a somewhat gradual development of the student through his preparatory school and undergraduate college days with a slight cessation of his progress as he enters college. This period of adjustment at the beginning of the college year has been of much concern to all educators, and it is my opinion that the problem has been pretty well solved whereby the student is given proper guidance in his early college days which helps him in his adjustment to a future environment.

A young man at the time of receiving his B.S. degree is an immature individual, with little experience in human relations and sadly lacking in discipline. The college can do much to provide proper discipline so that the individual can learn to respect authority, may become versatile with system and organization, and have opportunity in his four years in college to experience the problem of handling men as well as materials. I think that such conferences as this, where industry and the college sit in together to study the problem will help college teachers to realize the importance of broadening the field of engineering education.

Dean Case: To sum up in a sentence the result of this conference, I would say, that it is agreed that greater breadth in formal engineering education, without losing depth, is more likely to come through greater breadth and better coördination of the established courses now in engineering curricula, than by adding new courses taught by men who are not familiar with the objective set by the engineering school.

CONTRIBUTIONS OF MATHEMATICS TO RESEARCH IN PHYSICS AND CHEMISTRY*

By SAUL DUSHMAN

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To realize the importance of mathematics in scientific investigations of the present time, it is necessary only to glance over the contents in the various journals in physics and chemistry. Three centuries ago, Bacon said: "For many parts of nature can neither be invented with sufficient subtility nor demonstrated with sufficient perspicuity nor accommodated into use with sufficient dexterity without the aid and intervening of mathematics." Over a century later, Newton first demonstrated the power of mathematical analysis when applied to problems of celestial motions, and thus initiated a development in the science of dynamics which has been of far reaching importance in the subsequent development of all the other branches of physics.

It is of great interest to observe that with increase in the degree of precision in the determination of experimental facts, in any branch of science, there has also occurred an increased application of more abstract branches of mathematics. This is illustrated by the history of physics and the more recent developments in chemistry.

It is therefore no wonder that a famous scientist becomes so enthusiastic about the contribution of mathematics in interpreting the nature of the universe that he is led to write as follows:

> Our remote ancestors tried to interpret nature in terms of anthropomorphic concepts of their own creation and failed. The efforts of our nearer ancestors to interpret nature on engineering lines proved equally inadequate. Nature has refused to accommodate herself to either of these man-made moulds. On the other hand, our efforts to interpret nature in terms of the concepts of pure mathematics have, so far, proved brilliantly successful. It would now seem to be beyond dispute that in some way nature is more closely allied to the concepts of pure mathematics than to those of biology or of engineering, and even if the mathematical is only a third man-made mould, it at least fits nature incomparably better than the two previously tried.

We have already considered with disfavour the possibility of the universe having been planned by a biologist or an engineer; from the in-

* Presented at the Conference on Mathematics at the 46th Annual Meeting, S. P. E. E., A. & M. College of Texas, June 27–30, 1938.

trinsic evidence of his creation, the Great Architect of the Universe now begins to appear as a pure mathematician.

At a time when chemists were still attempting to answer the question "What is a homogeneous substance?," * the only mathematics needed was simple algebra. When they proceeded to investigate, "What happens when homogeneous substances interact?," they discovered the almost uncanny power hidden in simple differential equations. In the past decade, when chemists have sought to answer the question "How do the atoms and molecules interact? What is valence?," they have found that a solution in agreement with observed facts is obtained only by the use of operational methods and certain broad generalizations of the methods of calculus of variations.

Even the biologist has found that the methods of calculus and of the theory of probability enable him to deduce generalizations about the phenomena of life which are of fundamental significance.

To discuss adequately the contributions which have been made by mathematics to research work in physics and chemistry would involve a presentation of the whole field of mathematical physics from the time of Newton to the present. In fact, modern physical science would be inconceivable without the immense aggregate of mathematical technique, a part of which is discussed in such books as those of A. G. Webster's "Partial Differential Equations of Mathematical Physics," or the more recent work of Bateman on the same topic, R. Courant and D. Hilbert's "Hilfssmethoden der Mathematischen Physik," or F. von Mise's "Differential Gleichungen der Physik," and several other works.† In these treatises, repellant at first glance because of their symbolic language and abstract terminology, there lie, almost hidden from the sight of the casual observer, literally a thousand illustrations of the great contributions which mathematics has made to the development of physics and chemistry.

Some twenty years ago, H. Poincaré wrote a work entitled "Science and Hypothesis," in which the relationship between physical science and mathematics was presented from the point of view of one of the greatest mathematicians of that period. The following quotations from this book express adequately the manner in which mathematics, according to Poincaré, has contributed to scientific investigations:

"Experiment," he writes, "is the sole source of truth. It alone can teach us anything new; it alone can give us certainty.

* M. M. Pattison Muir, "A History of Chemical Theories and Laws," John Wiley and Sons, New York, 1909.

† *E.g.*, the treatise on engineering mathematics by R. E. Doherty and E. G. Keller.

. . . But to observe is not enough. . . . The scientist must set in order. Science is built up with facts, as a house is with stones. But a collection of facts is no more a science than a heap of stones is a house. Above all the scientist must foresee, and a good experiment is that which informs us of something besides an isolated fact; it is that which enables us to foresee, that is, that which enables us to generalize. For without generalization foreknowledge is impossible. . . ."

Thus, thanks to generalization, each fact observed enables us to foresee a great many others; only we must not forget that the first alone is certain, that all others are merely probable. No matter how solidly founded a prediction may appear to us, we are never *absolutely* sure that experiment will not contradict it, if we undertake to verify it. The probability, however, is often so great that practically we may be content with it. It is far better to foresee even without certainty than not to foresee at all.

One must, then, never disdain to make a verification when opportunity offers. But all experiment is long and difficult; the workers are few; and the number of facts that we need to foresee is immense. Compared with this mass the number of direct verifications that we can make will never be anything but a negligible quantity.

Of this few that we can directly attain, we must make the best use; it is very necessary to get from every experiment the greatest possible number of predictions, and with the highest possible degree of probability. The problem is, so to speak, to increase the yield of the scientific machine.

This, then, is the rôle of mathematical physics. It must direct generalization in such a manner as to increase what I just now called the yield of science. By what means it can arrive at this, and how it can do it without danger, is what remains for us to investigate.

Let us emphasize this point, which has often been forgotten, that mathematics cannot add to the experimental facts. It does enable us, however, to deduce, from the actual observations, generalizations and consequences, the validity of which may be tested by subsequent experiments.

In the initial stages of development of any branch of science, the application of mathematics consists mainly in the formulation of functional relations. We designate these as *physical laws.* Any such law expresses a relation between observed magnitudes which may be designated "pointer-readings." It will be remembered that Fourier, in his classical treatise on "The Analytical Theory of Heat," begins with the statement:

Primary causes are unknown to us; but are subject to simple and constant laws, which may be discovered by observation, the study of them being the object of natural philosophy.

So-called "laws of Nature" are merely quantitative expressions for certain uniformities which are deduced by observation. In any experimental investigation the initial effort involved is that of determining the exact nature of the factors involved, and eliminating unessential ones. In other words, the investigator attempts to determine the nature of both f and the independent variables $x_1, x_2 \ldots x_n$ in a relation of the form

$$P = f(x_1, x_2 \ldots x_n), \tag{1}$$

where P is some measured property.

Thus, it has been observed that in the case of a large number of properties of solids and liquids, the temperature dependence can be expressed by a relation of the general form

$$P = AT^n e^{-b/T}, \tag{2}$$

where A, b and n are specific constants which are determined in each case by observation.

Another large number of phenomena are found to obey a relation of the form

$$P = Br^m, \tag{3}$$

where r represents a distance, and B and m are again specific constants. In this relation m may assume both positive and negative values, fractional as well as integral. The most famous illustrations are Newton's law of gravitational interaction and Coulomb's law of electrostatic repulsion and attraction. But the same type of relation with $m = -7$, has been deduced for the van der Waals force of attraction between molecules in a gas.

In a recent address on "Mathematics in a Changing World," * Professor Arnold Dresden has emphasized the following four aspects of the science of mathematics: (1) its powers of analysis, (2) its concern with functional relations, (3) its abstract nature, and (4) its interest in invariants under transformations. While there are undoubtedly other features about mathematics that are of great significance in scientific and engineering application, I believe that the aspects mentioned by Professor Dresden are the most important from the point of view of the present discussion.

The simplest form of application of mathematics, as already pointed out, is that involving functional relations. Such relations may be derived empirically from actual observations, or deduced from theoretical considerations. Thus, the relation between vapor

* *The Scientific Monthly*, June, 1934, p. 568.

pressure of a solid and the temperature has been deduced from the second and third laws of thermodynamics, and similar considerations have enabled us to derive an equation for electron emission and a relation for rates of diffusion in metals as governed by temperature. In industrial design problems, we are making use constantly of empirical relations based on experimental data, and the instances of this nature are too familiar to require further discussion.

The use of analysis involves, in general, more difficult technique. As illustrations of the application of this aspect of mathematics may be mentioned the derivation of the distribution laws of Maxwell-Boltzmann, Fermi-Dirac and Einstein-Bose, the deduction by Clerk Maxwell of the theory of propagation of electromagnetic waves, and a host of other generalizations in physics and chemistry.

Usually the fundamental assumptions are presented in the form of a differential or integral equation, in which are involved boundary and initial conditions, and their solution often requires the use of broad, ingeniously devised methods and a familiarity with various types of approximations in the form of convergent series. Often the physical phenomena are quite complicated and all that the investigators may expect to accomplish by a mathematical analysis of the problem is a derivation of relations which are valid for certain limiting cases. Thus, the behavior of electrons and ions in a gas discharge cannot be discussed completely except in the most general terms. As has been shown in a paper by Dr. Tonks and Dr. Langmuir, there are five dependent variables which determine the characteristics of such a discharge. While it is possible to deduce five equations by which these variables are connected, some of these equations are of the integral form and cannot be solved readily except for certain limiting cases. These solutions, however, serve to indicate the nature of the results to be expected for the intermediate cases and thus enable us to derive a fairly comprehensive representation of the phenomena in a gas discharge. Furthermore, it has been found possible to arrange experimental conditions under which the relations deduced for the special cases may be tested, and since these observations agree fairly satisfactorily both qualitatively and quantitatively with the relations deduced theoretically, we have faith in the validity of the whole point of view.

I have used the work of Tonks and Langmuir as an illustration, because I happen to be more familiar with it, but, again, the scientific literature contains a host of illustrations from other fields of investigations.

The abstract nature of mathematics, its generality and independence of physical models or concepts, is one of its most striking

features and the most stimulating to the scientific investigator. That, for instance, the same differential equation applies to the vibration of a linear harmonic oscillator, to the high frequency oscillations in an electric circuit, and, in fact, to oscillations of any type, is extremely suggestive, to say the least. When we pass from this to the consideration of the interaction of two hydrogen atoms and recognize the analogy with two coupled oscillators, we find in the solution of the latter problem certain features which assist materially in the solution of the first problem.

The development of wave mechanics by E. Schroedinger provides an excellent illustration of the value of abstract mathematics in scientific investigation. In the middle of the nineteenth century, Sturm and Liouville developed the whole mathematical theory of boundary value problems. It was found that certain types of differential equations have characteristic solutions corresponding to so-called characteristic values of some of the parameters. On the basis of de Broglie's theory of the wave nature of corpuscular motion, Schroedinger was led to deduce a differential equation of the Sturm-Liouville type for the behavior of the electrons in an atomic system. Now the interesting thing about this equation is that while it is similar in form to that which expresses the amplitude of the wave motion Ψ, as a function of coördinates, this so-called amplitude and wave motion can have no physical reality. For Ψ may be a function of as many coördinates as are necessary to define the state of the system. In the case of a helium atom this would correspond to six coördinates, three for each electron, and to conceive of a wave amplitude in six dimensional space is obviously nonsensical. Under these conditions we interpret $\Psi\bar{\Psi}$, where $\bar{\Psi}$ is the complex conjugate of Ψ, as a probability distribution function, and the solution shows that $\Psi\bar{\Psi}$ can have finite values only for certain discrete energy values of the system. The analogy with the existence of nodes and loops in a stationary vibrating system is purely mathematical. From a physical standpoint the whole procedure of deriving the Schroedinger equation for any given case is utterly incomprehensible. It requires a great deal of faith in order to proceed with the actual solution of the equation, since we have no physical analogy for the mathematical technique. All that matters physically is the result of a complex sequence of operations executed according to certain rules, and the only justification for such a procedure is the fact that it yields results which are in better agreement with observation than those deduced by any of the previous methods which were based on mechanical models of the atom.

Yet this very abstract mathematical technique has led to an interpretation of such phenomena as those of valence, activation

energy, cold cathode emission and radio-active disintegration. On the basis of Newtonian mechanics or classical electron theory, these phenomena were completely incomprehensible, but they constitute logical consequences of the newer point of view.

While wave mechanics is an illustration of the application of abstract mathematics, it shows, by its very designation, an effort on the part of the theoretical physicist to assign to the subject a physical interpretation. The "wave mechanics" brings before us a picture of undulatory motions, of nodes and loops, of amplitudes and intensities, of phase velocity and group velocity, and we imagine that by such conceptions we have robbed the differential equation of its abstract features. However, this is only a self-delusion, for as shown by Heisenberg and Born on the one hand, and Dirac on the other, the Schroedinger equation is only a special case of a general problem in the theory of invariants.

This point of view is best understood by the following quotation from the preface to Dirac's "Principles of Quantum Mechanics."

"The methods of progress in theoretical physics," he writes, "have undergone a vast change during the present century. The classical tradition has been to consider the world to be an association of observable objects (particles, fluids, fields, etc.) moving about according to definite laws of force, so that one could form a mental picture in space and time of the whole scheme. This led to a physics whose aim was to make assumptions about the mechanism and forces connecting these observable objects, to account for their behavior in the simplest way. It has become increasingly evident in recent times, however, that nature works on a different plan. Her fundamental laws do not govern the world as it appears in our mental picture in any very direct way, but instead they control a substratum of which we cannot form a mental picture without introducing irrelevancies. The formulation of these laws requires the use of the mathematics of transformations. The important things in the world appear as the invariants of these transformations. The things we are immediately aware of are the relations of these nearly invariants to a certain frame of reference, usually one chosen so as to introduce special simplifying features which are unimportant from the point of view of general theory.

"The growth of the use of transformation theory, as applied first to relativity and later to the quantum theory, is the essence of the new method in theoretical physics. Further progress lies in the direction of making our equations invariant under wider and still wider transformations. This state of affairs is very satisfactory from a philosophical point of view, as implying an increasing recognition of the part played by the observer himself in introduc-

ing the regularities that appear in his observations, and a lack of arbitrariness in the ways of nature, but it make things less easy for the learner of physics. The new theories, if one looks apart from their mathematical setting, are built up from physical concepts which cannot be explained in terms of things previously known to the student, which cannot even be explained adequately in words at all."

As a result of this point of view, the new mechanics has developed a terminology of its own. We speak of observables and of operators. The energy of an atomic system is presented in the form of a relation between infinite arrays or matrices, and the problem is no longer that of solving a differential equation, but rather that of determining such a transformation that various successive operations will result in a diagonal matrix. The whole procedure has become a manipulation of symbols according to certain definite rules, and it is only the final result that may be interpreted physically.

As pointed out by Dirac, the concept of invariants is a guiding principle in the formulation of both the theory of relativity and the new quantum mechanics. It has arisen from the necessity for formulating relations between physical phenomena in such a form that they shall be independent of the observer. Mathematicians like Riemann, Cayley, Sylvester, Christoffel and Ricci prepared a groundwork upon which Einstein could base his general theory of relativity, and the more recent investigations of Eddington, Le-Maitre and de Sitter represent attempts to describe the laws of the universe from the same point of view, that is, as an application of the theory of invariants. In a world full of change and ever exhibiting the transient, the physical investigator seeks for the unchangeable and permanent elements. The mathematician provides the methods by which these ends may be attained.

As was stated at the beginning of the paper, the contributions of mathematics towards the development of physical science have been of fundamental importance. Without this contribution, physics and chemistry would still be in what we shall designate as the biological state. By this is meant no disparagement of the latter branch of science, but merely a description of the contrast in the methods used in deducing generalizations. We see that with increasing refinement of observation, it has been found necessary to replace relatively simple representations by more complex interpretations. And in this development mathematics has been called upon more and more for assistance, both in suggesting new concepts and in correlating, under broader generalizations, the increasing number of experimental observations.

As has been stated by a number of writers, mathematics is the language of science, par excellence. It is a language which has always provided a vocabulary by which man may express his highest intellectual efforts. There can therefore be no doubt that in the future developments of astronomy, physics, chemistry, and in every other branch of human activity, as they become more exact, mathematics will find an ever increasing field of application which, to transform a Biblical proverb, enricheth him who giveth even more than him who taketh.

THE ENGINEERING DRAWING DEPARTMENT—ITS ORGANIZATION AND DEVELOPMENT *

By IVAN C. CRAWFORD

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Formal organization of all activities, whether they be social, general business, or educational, is supposed by the outside world to be a distinguishing characteristic of the American. If there is such a characteristic, then it probably exists in the educational field to about the same degree that it is found in other environments. Discussions by university executives during recent years would lead us to believe that there are departmental boundaries which are not natural frontiers and that perhaps mistakes in organization have been made in the past and are being perpetuated in the present. Not many years ago a college president seriously suggested that a rather well established college of engineering give up its departmental organization through which it had operated for a period of forty years and become a department with one man to be known as a professor and with several teachers of various grades giving the instruction in civil, electrical, mechanical, and chemical engineering. In an occasional situation it is entirely possible that this plan might produce fair results. However, such a scheme of organization would take us back many years in our education development, that is, so far as engineering colleges are concerned, and appears to be a step backward—opposed to the experiences and progress of the past forty years.

As a specific instance, let us consider this question: Is it necessary, or even desirable, to organize a separate engineering drawing department in every engineering college? Looking about the country, we find occasional colleges in which there are no such departments. Engineering drawing and descriptive geometry in such cases are taught in one or another of the professional departments, usually in civil or mechanical engineering. As a rule, the colleges in which such a situation exists are rather small. The fact remains, however, that engineering students may gain a rather good professional education without taking work in a formally organized department of engineering drawing.

The primary reasons for giving instruction in engineering

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drawing and descriptive geometry are several in number and include:

(1) To teach the language in which engineering designs are expressed;

(2) To inculcate good study habits;

(3) To develop the student's capacity to visualize relationships in space. The organization through which these objectives are attained is relatively unimportant when compared to the objectives themselves.

To the writer, it is plain that under local conditions which are favorable, good results may be obtained without much organization. In spite of some exceptions, however, years of experience have demonstrated that there usually comes a time in the growth of an engineering school when the segregation of the drawing work into a department of its own promotes efficiency in instruction and helps to make the college become a more effective organism.

The Teacher

The vitally important factor in the teaching of engineering drawing and descriptive geometry is, as all will concede, the instructor himself. Such teachers occupy a post of commanding influence in an engineering faculty. For an entire year they are symbols of the engineering profession to the student since he does not normally come in intimate contact with other representatives of the faculty during this period. These students are high school boys, generally ambitious and filled with enthusiasm. The majority of them are away from home for the first time. Certainly to be really successful the instructor who comes in such close association with them should be young enough in mind, if not in body, to understand the mental situation of these youngsters and thus be able to interpret for them many subjects besides the technical one he teaches. He should, of course, have been trained in an engineering field and have had some practical experience. The classes should be of such a size that even when young and somewhat inexperienced assistants are employed, a more mature representative of the staff can become well acquainted with the students. A sympathetic interest in and an understanding of young men, in addition to an enthusiasm for work, are indispensable prerequisites for success in this field.

In the case where drawing courses are taught by instructors who also teach a course or two in the professional departments, there is danger that the drawing work may suffer on account of an erroneous idea on the part of the instructor as to the relative importance of the two divisions of his work. On the other hand,

in such a situation the instructor frequently brings to the drawing room a vitality which is of considerable value. In departments formally organized, the same desirable effect is secured when the instructors are able to secure suitable positions in engineering offices and on field work during the summer vacation period.

In formally organized engineering drawing departments, especially those containing a considerable number of persons on their staffs, there are usually one or two or more teachers who are permanent and who have professorial grade, and, in addition, a number of younger men of the instructor grade who do not, as a rule, look upon the position as a permanent one. During periods of normal engineering activity, the younger members of the department will have frequent opportunities to secure positions in industry and consequently the turnover in the department will be rather high. And this is as it should be; the abler young men need the outside experience and the less successful ones should not look upon the position as a permanent one. A similar condition exists in the personnel of separate departments of engineering mechanics and in the professional engineering departments to a somewhat less degree. Of course it is to the advantage of the department to be able to retain as high a percentage as possible of the instructors who have demonstrated superiority in teaching and in counselling students, and for that reason it seems that such a department could well have a rather high percentage of men of professorial grade. It is very unfortunate, however, when men who do not have outstanding qualifications for this type of work are retained and automatically advanced in salary and grade. Soon the department becomes loaded with individuals who do not form proper contact points for the college of engineering and who, as a rule, confine their activities to a very narrow routine of departmental duties.

Counsellors

When properly manned, the engineering drawing department makes an excellent agency to conduct counselling work for freshman students. This work is most important because intimate contact with the individual is more difficult during the freshman year than at any other time of the student's career in college. At many institutions, freshman students are assigned to advisers picked from the different engineering departments. Even in the case where the adviser is very enthusiastic about his work, he sees the student only at rare intervals and a special effort must be made by the student and by the instructor also in making a suitable meeting date. Instructors of the engineering drawing department meet these students for considerable periods of time and

on two or three occasions a week. Consequently, they should be able to do such work, in case the instructor is properly qualified, with much less effort and usually with a better knowledge of the student's capabilities than student counsellors who are not constantly in contact with the student. For these reasons, it is advisable that the more experienced members of the engineering drawing department staff should carry a relatively light instructional load and that a considerable proportion of their time should be devoted to the counselling of freshmen.

In following through the growth of an engineering school over a period of forty or fifty years, we should probably find that engineering drawing was first offered by a member or members of the older engineering departments, men who frequently had other duties to perform. In a number of institutions, this is the status today. Usually, however, as the enrollment and breadth of instruction grew, an engineering drawing department came into being for the reason that instruction could be more efficiently given by setting up such an organization. With the improvement in organization came the weakness of specialization on the part of the personnel involved, or at least an opportunity was presented for this weakness to creep in. Such a condition can only be avoided when instructors keep up a lively interest in their branches of the engineering profession.

In recent years there has been a tendency to give to the engineering drawing department additional duties. The department head, assisted by selected members of the staff, may become the counselling agency for freshmen of the engineering college. Those familiar with such an organization feel that it works very efficiently. To be successful in this work, the department must have staff members of rather exceptional qualifications, not the least of which is a sympathetic understanding of American youth.

THE OPPORTUNITY TO INSTILL ENGINEERING SPIRIT IN FRESHMEN AS OFFERED IN THE TEACHING OF ENGINEERING DRAWING *

By A. MITCHELL

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D. S. Anderson, former President of the S. P. E. E., in his address delivered at the 44th annual meeting stated, in substance,

* Presented at the Conference on Drawing and Descriptive Geometry at the 46th Annual Meeting, S. P. E. E., A. & M. College of Texas, June 27–30, 1938.

that it is a specific function of the engineering school to provide means by which the student may develop his personality and his character. Later in the same address he emphasized the importance of having a teacher himself possessed of the warming fire of personality and character and through the medium of one of the regular subjects in the curriculum, so instill into the students a love of truth and a sense of responsibility to the particular task in hand that it cannot fail to be a significant influence toward the development of character.

This sense of responsibility about which he speaks should find its inception at the very beginning of the freshman year and no subject in the curriculum is better calculated to instill that love of truth and sense of responsibility in the freshman engineer than engineering drawing.

It is his first taste of engineering and leads him out of what he regards as a maze of high school routine in which he finds no particular interest, into a field of technical knowledge which he is at once ambitious to explore. It is fascinating to him and commands his lively interest because it involves mainly manipulative operations and not profound mental activity. It is inspirational to him if he is brought early in the course to appreciate the fact that it is fundamental and, in a very special way, prepares him for later courses in his curriculum.

All the courses may not require expert draftsmanship but the instructor in freshman engineering drawing should strive to develop in his students the ability to execute neat lettering, to lay out his work attractively, to understand the conventions thoroughly of shape and size description and to acquire a speed and a technique which will be an asset to him in any engineering office.

To accomplish these things regular and frequent drafting room practice periods must be provided. The student should be encouraged to purchase high quality drawing material and instruments and to take pride in their possession, care and use. He must have called to his attention constantly the fact that the skill and excellence which he is able to acquire early in his freshman engineering drawing will not only qualify him for superior work throughout the remainder of his college career but will be a decided professional qualification to him in after life. When he is brought to a proper appreciation of this excellence and skill he is fired with an enthusiastic spirit that is a prerequisite to success.

The influence to instill spirit in students and the effect of successful accomplishment upon their lives were eloquently and forcefully stated by William E. Wickenden in his address at the 1930 meeting of the S. P. E. E. from which I take the liberty to quote the following:

One of the responsibilities of every engineering teacher is to make learning inviting to his students. By this I do not mean to sugar-coat it, but to develop in the student an appetite for learning in its pure state. This end must be accomplished largely by personal influences. The student must discover in the teacher personal qualities of a highly desirable type that will consciously or instinctly link with what the teacher is trying to give him. Unfortunately some of the most learned men are, in their personal qualities, poor salesmen for learning. In a real sense the teacher is the goods in his own show window. We all know of a self-conscious culture which repels red-blooded men, but breadth of interest, vividness of personality, alertness of mind and a keen relish in living make an instant impression on the student in favor of the type of learning a man professes. A taste for learning grows from one's sense of accomplishment. The thing every bewildered and wavering freshman needs more than anything else is a taste of successful achievement.

The resourceful teacher will recognize the necessity of creating in his students a deep interest in a thing before he is able to instill in their minds a thirst for knowledge of that thing.

Engineering drawing immediately appeals to the interest of students. It is a pleasant and fascinating introduction to the study of other engineering subjects and it at once creates in their minds an ambition to go forward in their search for engineering knowledge.

The drawing teacher should not fail to point out to his students the practical applications and uses of every possible graphical construction. In geometrical constructions, for example, he should call attention to the value of the principles of tangency in their application to belts and pulleys, spurs, gears, etc. He should stress the graphical constructions that have to do with kinematics, forces, moments, stresses, etc. and should illustrate the value of charts and graphs in recording engineering data.

Descriptive geometry can also be made inspirational to engineering students. Their interest in it is excited by the high degree of accuracy with which the constructions can be made and the susceptibility of the number of solutions applicable to most problems; also by the many unusual and apparently phenomenal facts which are so new and strange to the beginner that his excited interest almost drives him to doubt their authenticity. For example, one line in a plane can fix the position of that plane perpendicular to another plane, the projections of the bisector of an angle do not always bisect the projections of the angle, parallel lines are always seen parallel but perpendicular lines are not always seen at right angles to each other, a line parallel to the picture plane in perspective has no vanishing point, etc. These facts and numerous others in Descriptive Geometry, draw out the student's mind, develop his imagination, enlarge his quality of vision and enable him to analyze

his problems in engineering as perhaps no other course in his curriculum can do.

Vision is the product of enlarged and systematically developed imagination and this endowment is essential for any design engineer. Before any project of construction or manufacture is undertaken the designer must have in his mind's eye every detail of the structure with its relation to every other part and to the whole, even before he can complete his design in the drafting room, there must stand out in his imagination, the entire structure complete in all of its intricacy, perfection and beauty.

The good teacher of engineering drawing will lead his embryo engineers into a larger spirit of their profession if he can bring them to fully appreciate this dual responsibility—to design and to describe.

An engineering spirit in freshmen can come only after their interest, vision and purpose have been fired by the zeal and enthusiasm of a teacher who constantly radiates the warmth and exhilaration of his own personality. He must have the spirit himself before he can fire the student's heart.

Discussion

By C. E. ROWE

Professor of Drawing, The University of Texas

Professor Mitchell has treated the subject in a thoroughly satisfactory manner and I find myself in agreement with all he has said. The subject, however, is of sufficient importance to justify some repetition or amplification. Upon reading the title of the paper I began to wonder just what is "Engineering Spirit." Inquiry among my colleagues revealed the fact that, although they thought they knew, none of them could define the term. "Spirit" as used in this connection may mean, first, the characteristic quality or the controlling principles of engineering; second, an enthusiastic loyalty to the profession. At the University of Texas the engineering students exhibit something akin to the second definition in their demonstrations of loyalty to the College of Engineering as contrasted to their attitude toward the School of Law. We do not need to instill loyalty into our students. It is a by-product of the study of engineering. Therefore, this discussion is based upon the assumption that we wish to impart constantly throughout the freshman year something of the essence, principles, and ideals of engineering.

The freshman course usually consists of English, chemistry, physics, mathematics, and drawing. English for engineers could and should be taught so that students may do much of their theme writing about things engineering. Unfortunately, we do not have

many English teachers who realize that they could inspire these students to do better work by giving their course something of an engineering flavor. Teachers of chemistry, physics, and mathematics have an opportunity to enliven their courses with engineering applications, but they usually are not engineering graduates and are not greatly interested in correlating their work closely with engineering.

Of all the courses studied in the first year, drawing and descriptive geometry together offer an introduction to engineering. The student is interested at the outset of a course in which he can use both his hands and his brains. He learns to be neat and accurate in his work. He is made to realize that constructions on the drawing board, as in engineering, must be true in principle and accurate in execution. Throughout the course the authority of truth is being demonstrated both in the lecture room and in the drafting room.

He studies the graphic language and begins to understand drawings which express creations of the mind of an engineer such as he hopes to be. He learns to express himself in this language and appreciates the efficacy of accurate and concise description, which is superior to the possibility of his native tongue. He learns that there is a choice of expression in that he may use pictorial methods for the layman, and orthographic drawings for engineers and artisans. If he has selected the latter method, he finds that he must give careful consideration to his description by selecting the best views and arranging them in the most satisfactory manner so as to show the object definitely and most effectively.

He develops a sense of proportion, size, weight, and volume useful to him in his career as a student and as an engineer.

The drawings he makes require planning—thinking through the whole project and visualizing the completed sheet with its various views, dimensions, and notes arranged in proper order. This is the type of thinking the engineering mind must be trained to do. Having planned the project, further engineering training is provided in the systematic procedure required for its execution. Finally, when he has completed the drawing neatly, accurately, and with the speed which his skill permits, he feels a pardonable pride of accomplishment comparable to that which the engineer feels upon the successful completion of a great structure.

His training in visualization begins in the drawing course with the study of the representation of objects and continues with increasing effectiveness in working with the spatial relationships of points, lines, and surfaces as treated in descriptive geometry. The power of visualization is a characteristic of the engineering mind, and is most important to the designer of machinery, structures, and

industrial plants. It may be developed to a greater degree in descriptive geometry than in any other course provided the subject is made interesting by enriching it with numerous engineering applications. The study of descriptive geometry develops the ability to analyze problems, to plan their solutions, and systematically to carry out the required constructions with neatness, accuracy, and efficiency. The student should acquire a sense of mastery of the problems of space.

Almost at the beginning of an engineering drawing course the student finds that the field of engineering is beginning to open to him through a study of the objects he draws. Although he may not understand how they are designed, he knows that engineering principles are employed and that he will learn to use them to his own satisfaction and profit. His teachers are engineers by training and experience. He is getting into the profession of engineering. The drawing teacher should take advantage of this favorable attitude of mind and make the most of his opportunity to instill the spirit of engineering by correlating his work with that of surveying and mapping, machine design, building construction, structural engineering, manufacturing, industry, and mining.

By CLAIR V. MANN

Professor and Head Dept. of Engineering Drawing, Missouri School of Mines

Professor Mitchell certainly is to be commended for the presentation of such an excellent paper as he read on the subject in hand. I shall outline the main features of a plan we have been trying in a practical way to carry on at Missouri School of Mines. The plan was initiated by and under Charles H. Fulton, former Director of the institution.

I think most of those present know, without my going into great detail here, something of the general scope and purpose of the "selection and guidance" work we have been doing at Rolla. First, a brief statement of our basic set-up. During Freshman Week, in the fall, we administer the Iowa Placement Tests in Chemistry, Mathematics, and English, and the Mann Drawing Aptitude Test and several of Mann's tests of power to visualize. We also give Strong's Vocational Interest Test. All the results from these tests are graphically portrayed on individual student cards, made out and on file in our Drawing Department office. Sections in Drawing, as well as most of them in English and mathematics, are made up on the basis of student ability. There are sections especially for the "high" students; different sections for the students of "medium" ability; and "low" sections for those who have done poorly on the placement tests. In theory, if not

altogether in fact, these different sections are taught in accordance with their several needs and types of ability. The goal is very definitely to *"inspire"* the superior students. They are taken over much more ground than students of other sections, and subjected to less of the "drill" or "drudge" type of drawing problem. All students in the high sections are encouraged to look at and study their own record cards, and so to know what are their points of excellence and also their weak spots, and where is the chance for improvement. They also study their own card in relation to those of their classmates—they exchange their cards and get an idea of what the other boy is like.

The superior students are given outlines of a very large engineering business, for which they are to select, from among their own number, the several classes of engineers who are to have charge of the business. First, they must select a President and a Board of Directors. There must be a Chief Engineer. There is a Departmental Engineer for each of the following aspects of the business: (1) Design; (2) Research; (3) Maintenance and Operation; (4) Management; (5) Finance and Accounting; (6) Construction; and (7) Sales. Under each of these seven departmental heads they must choose two other engineers as assistants. The students turn in, each for himself, a selection of freshman students to make up such a staff for the business. This project is worked out after the students have been together for perhaps two months, and have a good idea of one another's characteristics and capabilities. In doing this work they have access to our file of personnel cards. This project, as well as the others that follow, is carried on only with classes of superior students.

Lettering is the first topic taken up in class, and here comes a first opportunity "to instill engineering spirit." When the students have gained some proficiency in lettering, they are required to letter on a nice card of appropriate size the definition of engineering that was given by Telford. They are told who Telford was, when he lived, what work he and his colleagues did, and of modern extensions of his definition—notably that one written by the S. P. E. E. Committee on Coördination in its 1926 report. This gives opportunity to speak of the early beginnings of engineering and engineering education, and their present state. A wonderful opportunity presents itself when another similar card is lettered, on which they print the words of the renowned Benjamin Lamme: *"The engineer looks to the future, and views hopefully the hitherto unattained."* This chance is taken to tell them about S. P. E. E. and its meetings, and its selection each year of an outstanding engineering educator who receives the Lamme award. We tell them who Lamme was and what he did.

Our particular instructional staff has been so chosen that it represents many engineering viewpoints. Every man in the department has had first hand engineering experience—a thing we regard as positively essential in selecting new members of the staff —and so can present problems for the class that have been drawn from his own personal experience. This fact seems to have its appeal for the students. Our most recent addition to staff is a practising and practical architect, who also knows engineering, so that our staff training and interest now thoroughly covers civil, mining, mechanical, and architectural practise, and to a less extent electrical, chemical, and metallurgical.

Also in conjunction with the teaching of lettering, we have brought into class copies of *Engineering News-Record*. The students have been asked to look at the engineering drawings contained in the several issues presented, and to observe the character of lettering used, and the general nature and quality of the drawings. Mechanical Engineering magazine is also brought to class, with others of like character. This gives opportunity to speak of the work of Mr. Charles Reinhardt, and why he devised the "Reinhardt" adaptation of the Gothic style of lettering—often referred to as "Engineering News Print." This lesson gives the boys an early interest in reading their professional engineering magazines. Along with the magazines we occasionally secure numbers of copies of the catalogues of manufacturing firms which they can examine. These include catalogues of diesel engines, turbines, core drilling machinery, air drills, turbines, air compressors, locomotives, electrical machinery, civil engineering construction machinery, and so on. We also bring to class several well selected sets of actual engineering plans—one for a large building; another for a sewage disposal plant; another for a large stone crusher; another for a locomotive engine; and others for airplane construction. These emphasize—help us to emphasize—good quality of delineation and lettering—which they observe on the plans selected.

Another opportunity to instill engineering spirit and interest comes when work is started on the drawing of machine parts. We have in the department several books dealing with the history of the early tool builders—those in England, like Maudsley, Nasmythe, and Whitworth, and James Watt and his engine building experiences—and those others in America, like the Yale and Towne company, Brown and Sharpe, the Starrett Company, the Baldwin Locomotive Works, and so on. Whitworth and Sellers threads take on a new meaning after this lession. At this point also we can speak of Leonardo da Vinci, and his qualifications and works as engineer, artist, sculptor, anatomist, and eminent pure scientist, and can exhibit some of his freehand sketches of machines and of

notions of airplanes he had. This presents the opportunity to explain how the early tool builders made—and how the student himself might make—the first turning lathes, the first planer beds (flat planes), the first accurate screw threads, and the first steam engines.

Departments of engineering drawing which can do so should arrange to invite Richard S. Kirby, of the Drawing Department of Yale University, to visit them and present his most excellent lectures covering Engineering History. From my point of view every engineering student should be interested in taking—should be required to take—a two- or three-hour course in Engineering History. Our times and our profession need this. Certainly such material should be well covered in any "course" or series of lectures pretending to be *"an orientation course."*

On other occasions we have stimulated engineering interest in our drawing classes by taking them to the main auditorium where there could be shown to them various movie films that illustrated various engineering processes, construction, or machinery. Perhaps one of the best features of our plan, and one we are at present most actively working on, is the encouragement of evening meetings for the students in freshman drawing classes. Our plan is to conduct a series of meetings for this group that are essentially like the various "American Society" meetings carried on, for instance, by the student chapters of American Society of Civil Engineers. Freshmen do not ordinarily get into these student society chapters, *and they decidedly do have a desire to attend meetings of this order. There should be originated a national society of science and general engineering* for the benefit of freshman engineering students.

Prior to such meetings our students appoint their own program committee, select a series of speakers from their own number, invite those chosen to write and present papers dealing with some topic of mutual interest, arrange for a light luncheon following the meeting, and then call the meeting and carry out their plans. It has been possible to note a decided "pick-up" in professional interest in engineering following these meetings. Moreover, the meetings tend to promote general friendship and acquaintance among the students, and have in a number of instances resulted in the forming of close, intimate friendships that will without doubt continue throughout a lifetime.

A program that was carried on some years ago, by all the superior students (78 of them) in descriptive geometry, featured a Saturday picnic on a mountain stream some nine miles from the School. The object of the trip was both to have a class picnic, and to work up a practical problem in descriptive geometry. With the

instructor a committee of the class visited a spot where there was uncovered a considerable outcropping of a rock ledge which had been heavily "faulted" in ages past. The fault plane had considerable "dip," and the class was to determine the "strike, dip, and direction of dip," and trace the outcrop of the fault plane across a small oval hill. The class, equipped with two transits, tapes, stadia rods, drawing boards, and other accessories, and with a splendid basket lunch prepared by the two "coed" students in the class, went to the spot in cars and busses. A topographic survey was made of the hill, points were located from which the fault plane could be plotted on their problem sheets, and eventually the class made a complete topographic map of the oval hill and of the valley crossed by the fault. Final details of the problem were worked out in the classroom. This project instilled a real and lasting engineering interest in the subject of descriptive geometry in the students—and made them feel they had used the subject on a very real engineering problem. From that year on the writer has noted a cessation of the loss to the school of a high percentage of superior students—which in previous years had "flunked out," or had transferred to some other school. Features that have also "instilled engineering spirit" into students of drawing in our school have been the two industrial trips conducted each year since the fall of 1931.

And while we speak of that vague and uninteresting (?) thing —English!—let me recall for you an experience I had a few years ago when I was developing some new teaching material in descriptive geometry. I had not the time to sit down and write out the materials incorporated in my lectures, so decided to employ a real expert typist and stenographer—one who could take a three-hour lecture (!) in its entirety. When she turned in her first typed manuscript, and I read it, our idea of her ability dropped to very low ebb. Surely we had never used such awful English as her manuscript revealed! We were almost ready to fire her, but first decided to have one more try, this time watching for ourselves the kind of talk we were delivering. It did not take long to convince ourselves that the manuscript was right—the lecturing terrible. There was frequently no sentence structure—no unity—no correct usage of words. There were frequent interjections of "See? See? See?" That was the beginning of some very serious self improvement on the part of the teacher. We now think the engineering student has every right to expect his drawing teacher to use good form in his usage of English in the classroom lecture! And it is the positive duty of each and every Drawing instructor to examine and listen to his own lectures, as they proceed, and eliminate the excess of "See-see-see"s he may be using. These teachers, like some others we could name, also very definitely need a good

course in *"Speech,"* to train them to modulate their voices, and quit talking from between their closed teeth, so that their students can hear what they say.

Finally, and in connection with this business of "instilling engineering spirit" into students of drawing, the premise is taken that the teacher of such bright, live, interesting, worthy students should himself be in every way worthy. His personal life ought to measure up to the ideals of the profession of engineering—he himself should exemplify that "character" so often specified by mature engineers as the chief ingredient in a budding engineer. The teacher of freshmen needs to have specific engineering practise, broad professional and educational interests and outlook, great sympathy with youth and its highest aspirations, understanding and tact in and out of the classroom.

What finer thing could a drawing teacher do than the late Dean Ketchum used to do with his students of civil engineering? He and Mrs. Ketchum entertained classes of some thirty-five students at a sumptuous evening dinner served in their home. Here was perfect understanding and comradeship between a great teacher and his students. Inspiration supreme in the things not only of the engineering curriculum, but in fineness of life and of living! Would that there were engineering drawing staffs who could envision their opportunities like these for instilling engineering spirit into their students, and who would "pay the price" by giving their lives to their students *and to their profession of being teachers of students* (and of engineering drawing). Would that there were Deans and Boards of Trustees *who would pay teachers of freshmen and of engineering drawing salaries sufficient to enable these men in these ways to contact and inspire their students!* Then and thus would be solved the problem of instilling engineering spirit—of interesting students in engineering, and in the finer things of life the profession of engineering is today demanding that its recruits shall bring to the profession! *There should be no better, no higher paid teacher in the entire school of engineering than the teacher of engineering drawing!*

THE USE OF MOTION PICTURES IN ENGINEERING EDUCATION *

By GEORGE E. TOMLINSON

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The development of the motion picture process in 1894 has added materially to the effectiveness of visual materials as a means of learning. With this apparatus it is possible and convenient to depict observable action and the continuity of processes and events. Even more important from an educational viewpoint, it has become possible to bring out otherwise unobservable actions by means of animation, slow-motion photography, time-lapse photography, photomicrography, and miniature photography.

The early uses of motion pictures were confined almost entirely to the commercial theatres and were not used to any great extent in our educational programs. Perhaps the greatest impetus to the use of motion pictures in education came with the introduction in 1923 of the 16 mm. size equipment. Film in this size has a much lower initial cost than the commercial 35 mm. size, and the reduction in maintenance and transportation costs is also very substantial. Using 16 mm. film it is possible to include a whole hour's program on one reel for continuous showing without interruptions to change reels or the necessity of using alternating projectors as is done in the commercial theatres. The fact that all 16 mm. films are printed on a safety base, whereas most of the larger films are on nitrate or inflammable stock, is another decided advantage. Synchronized sound effects, originally introduced to the public only in the 35 mm. size in 1927, are now equally satisfactory in both sizes.

No inventory of projectors in use by engineering colleges is available, but a survey in 1936 revealed that the U. S. high schools owned and operated approximately 10,000 motion picture projectors, of which 6,500 were of the 16 mm. size and 800 were equipped for reproducing sound. It is probable that, for educational purposes, the 16 mm. size film and particularly the sound-on-film type will be the film of the future.

Visual material should supplement and not supplant existing methods of instruction. The aim should be to secure appropriate

* Presented at the Conference on Instructional Methods at the 46th Annual Meeting, S. P. E. E., A. & M. College of Texas, June 27–30, 1938.

and timely pictures to fit the subject matter rather than merely to exhibit any pictures which may be available. Some educators have believed that the increased use of motion pictures in education will create a tendency to mechanize education—that is, to let the pictures do all of the work for the instructor with the result that fewer and less able instructors will be needed. This is certainly not the case. The proper use of motion pictures requires considerable preliminary and follow-up work with the result that the work of instruction may actually be increased. What is more important, the proper use of visual aids should make better teachers of our instructors.

Assuming that a central agency has been established and is able to make definite recommendations on all films, a great deal of work remains to be done by the instructor in fitting the best and most appropriate pictures to his particular course. After the films have been selected, a well-chosen list of reading materials should be made available in advance to the students, and an adequate evaluation should be undertaken immediately after the program. A satisfactory follow-up might consist of one or more of the following:

1. Detailed discussions.
2. "Yes or No" questions.
3. Questions calling for brief answers.
4. General oral or written reports.

A general engineering orientation series might constitute a proper start in the selection of films for engineering educational purposes. Another series might be prepared to cover the manufacture, characteristics, and uses of building materials. After these general topics, a detailed series of films dealing with each of the major branches of engineering should prove very useful. These are only suggestions. It is probable that a great deal of study and experimentation will be necessary before well-integrated series are evolved.

A number of engineering schools are located at great distances from industrial centers. At these institutions the proper use of educational film will fill a real need in building up an industrial background for the students. It is not unusual for an engineering class to make inspection trips of several hundred miles to visit bridge construction, hydroelectric developments, steel and cement mills, manufacturing plants, or other projects of engineering interest. In at least one instance, a senior class travelled more than 2,500 miles on such an excursion. The continuance of these inspection trips emphasizes the strong desire to build up a general knowledge of modern engineering methods and materials; and while it is not suggested that series of motion pictures replace these

trips, it is thought that the proper selection and presentation of motion picture programs could increase their value. They will be of even greater relative value to students in schools which do not sponsor inspection trips.

With suitable use of motion pictures, students in one part of the country may become better acquainted with engineering methods and projects in other localities. For example, students from the Deep South can better understand the difficulties of winter construction in the Northern States, and Eastern students might "see for themselves" the irrigation works so widely used in some of the Western regions. This type of information is important because, despite the fact that many graduates remain permanently in areas near their alma mater, a large number eventually move to places far away.

The lack of good motion pictures now available discourages purchase of equipment, and the lack of equipment discourages production. This vicious circle has been a serious obstacle in the development of educational films. Development of a satisfactory system of distribution can break this circle and is needed to overcome other handicaps such as:

1. Lack of information on available films.
2. Unintentional use of inferior films.
3. Inaccessibility of many good films.
4. Consequent unwillingness of school administrators to provide an adequate budget for the proper development of a visual education program.

A satisfactory distribution system can also make possible the securing for engineering education purposes of a number of new productions ready for release; that is, independently produced films, industrial films, government films, and university and college productions.

The Educational Motion Picture Project of the American Council on Education has undertaken to establish evaluating and experimental centers throughout the country to determine the values of existing films, the needs for new production, and the best methods of classroom utilization; but as yet the distribution problem remains without definite attempt at intelligent solution.

The American Council on Education is dealing primarily with subjects of general and elementary nature and for this reason their present program cannot offer maximum benefits to engineering education. It is hoped that our Society will join with the American Council on Education and do for engineering education what the Council is doing for general and elementary education.

The U. S. Bureau of Mines and one or two other agencies have

established distribution centers for "industrials" and similar films. They have strict editorial requirements, foremost of which is the stipulation that all films handled by them be free from obnoxious advertising material. They are doing good jobs as "booking offices," and their methods should be studied by everyone interested in educational film distribution systems.

A proper distribution system should do more than a mere booking agency. It should have facilities to:

1. Maintain lists of all available films on engineering subjects.
2. Prepare unbiased evaluations and make definite recommendations on each film.
3. Render assistance in the preparation of recommended supplemental reading materials.
4. Render assistance in recommending means for evaluating the local reception and results of each program.
5. Purchase, lease, rent, or lend prints coöperatively, thus effecting reduced costs and stabilizing the market for educational films.
6. Promote new films and determine the needs for new films.
7. Provide a permanent organization to carry forward research activities to promote best educational methods and results.

The proper selection of a complete series of motion pictures on any one engineering topic is a major undertaking because entire series of programs should be planned in advance and coördinated for the purpose in view. There are relatively few existing motion picture films which are entirely satisfactory in their present state. Then too, may of the better films prepared by independent agencies such as the Eastman or Erpi Companies are either too elementary for engineering instruction or depict experiments which can better be demonstrated in the college laboratories. A number of films, notably those produced by our larger industries, are very satisfactory in parts, but many of them contain such a large proportion of advertising matter that they are not suited for educational purpose.

After studying all available film and utilizing the existing material that can be fitted into the desired sequences, it is probable that there will be a number of gaps which should be filled by new productions. In the production of new films, as in the selection of existing ones, great care should be exercised to insure every education production being produced and maintained on a "professional" level. Amateurish film can become an effective teaching medium locally in the hands of the person who prepared it, but in the hands of others the results are apt to be unsatisfactory. This does not mean that production of educational pictures is beyond the ability

and resources of our educational institutions. Chicago, Harvard, Minnesota, Ohio State, Wisconsin, Yale, and other leading universities have produced a number of very successful educational films. Considering their dates of production, they are all worthy of highest praise. However, the production of creditable educational pictures for general distribution is more than a hobby and should not be undertaken until adequate personnel and finances have been secured. I am informed that the University of Minnesota is currently producing 10 pictures in the field of general education which are estimated to cost more than $12,000 each. Funds for this program were made possible by a grant of $122,600 from one of the national foundations.

The best immediate progress can probably be made by working with the producers of industrial film and editing existing "industrials" to meet educational needs and requirements. Should our Society sponsor a library of several series of engineering films, it is not improbable that some of the leading engineering societies such as the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, and the American Institute of Chemical Engineers would assist in the work relating to their particular fields. It is also possible that one or more of the national foundations would contribute to such a project.

There is considerable interest in the use of motion pictures in education, and we who are vitally interested in improvements in the methods and achievements of engineering education should leave no stone unturned until this new instrument has been thoroughly analyzed. If it is found to have merit, we should work diligently to utilize it most effectively.

In the brief time available during this meeting we can touch only a few of the major problems involved. It is hoped that a committee will be created to undertake a detailed study of the use of motion pictures in engineering education and to present a comprehensive report to the 1939 meeting. This report should include, among other things, answers to the following questions:

1. Is the use of selected motion picture films recommended as an aid to engineering teaching?
2. What films, suitable for use in engineering curricula, are available?
3. What is the attitude of independent and industrial producers towards coöperation in such a movement?
4. Should the selected film be collected in some central library or should the interested schools be referred to the numerous existing distributors?

5. Should selected reading and test material be prepared by some central agency for use with each program?

6. Will the leading engineering societies and national foundations lend any assistance to the establishment and maintenance of an engineering film library? If so, to what extent?

7. What will be the cost of an adequate program during the first year of operation and during subsequent years?

8. How can our Society coöperate best with other agencies in improving teaching technique through the use of motion pictures?

ON TEACHING HISTORY TO ENGINEERING STUDENTS*

By C. M. CORRELL

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A few years ago one of our college deans was obliged to report that a certain student who was enrolled in a specialized curriculum was doing unsatisfactory work in a course in English and in some of his other non-technical work. The reply from the guardian of this student was an interesting letter, from which I quote the following excerpts: "Of course," he wrote, "teaching Rhetoric to engineers and aggs. is one of the most discouraging tasks ever undertaken by mortal man, and anyone who had a choice probably wouldn't try. Herman Schneider, Dean of Engineering at Cincinnati, came back from war work at Washington with the profound conviction that the engineering profession failed to get the recognition it deserved because it didn't know how to sell itself. It's personnel hadn't the gift of gab, and refused to learn the mechanics of English so they could speak correct sentences or write decent letters. Dean Schneider went out and combed the universities for the best English and history teachers he could find, and persuaded the regents to pay them enough additional salary so they would be willing to struggle with engineering students. The dean did not hesitate to tell the boys, in season and out, that it wasn't their engineering training they needed to worry about, but their English and their cultural background." The writer of the letter goes on to say that Dean Potter, then of Kansas State, now of Purdue, confessed to the same experience. "When he tried to place his graduating students with industrial firms, he was told that his students were entirely adequate as to their engineering preparation but they were terrible in English and in savoir faire." "But," concludes this student's guardian, "try to tell that to a student in one of our technical schools and he will laugh at you, and the tragic part of it is that he will pay for his deficiencies all the rest of his life."

I introduce my part of this symposium with these rather lengthy quotations, not because this group needs to be convinced of the

* Presented at the Conference on Instructional Methods, at the 46th Annual Meeting, S. P. E. E., A. & M. College of Texas, June 27–30, 1938.

desirability of more liberal and cultural work in the technical curricula, for, if you were not concerned about these matters, you would not have set the theme for this convention as I see it on the program, nor would this afternoon's symposium have been arranged; but I would call your attention to the fact that the rather severe criticisms of engineering education contained in the words I have quoted, came, not from teachers of history, government, or English, but from leaders in your own field. I am simply repeating and re-emphasizing these shortcomings in engineering curricula in order, if possible, to stimulate you to exert your efforts in helping to effect needed reforms.

In behalf of history as an essential factor in the liberal education of technical students, I could argue at length if argument were necessary, but I shall assume that it is not necessary before this group. Even an engineer is, first of all, a citizen of the republic, and it would seem to go without saying that the greater the insight into, and the appreciation of history one has, the more intelligent and effective his citizenship is likely to be. One of my colleagues—a teacher in one of the science departments—recently remarked, rather facetiously, that he thought all history courses should be thrown out of all college curricula because people don't seem to profit from the lessons of history. My comeback to that remark was that, on the contrary, more history courses should be required of all students so that a larger number of citizens would have a more adequate guide in the intelligent exercise of the duties of citizenship. I recall the following incident and cite it, not as exceptional, but rather as typical of the practical effects of popular ignorance of history. I heard a United States senator campaigning for reëlection and he was telling his group of electors, with great senatorial oratory and bombast, how the panic of 1893 was caused by the reduction of the tariff. Of course he was trying to capitalize on the ignorance of the people, most of whom did not know, as he certainly did, that the act of congress reducing the tariff was not passed until a year after the panic broke. There may even have been in his audience some trained engineers who fell for his demagogery.

But college history instruction cannot function in the training of citizens unless we can get students sufficiently interested in it to demand that it be included in college curricula. In order to arouse that interest, we history teachers have to be concerned about methods and materials when we do get a chance at a class of students who are inclined to think that their college years must be spent in securing only highly technical training.

May I, therefore, make a few observations based on my experience in trying to stimulate the interest of engineering students in

history, and, I assure you, that, as Shakespeare says, "It is easier to tell twenty what it were well to do than to be one of the twenty to follow my own instruction."

In the first place, it seems obvious that history should not be presented to a class of engineering students in the same way in which it would be taught to students who are majoring or minoring in the subject. The history major must dig deep in the subject and must master much dry as dust material if he is going to be able to speak with some authority, or if he is to follow out a more or less elaborate sequence of courses. This is not true of the technical student who has time for only a limited amount of work in this field. Perhaps two or three basic considerations should guide the teacher in the selection of subject matter for emphasis. One of these is that we want the young people to have a working knowledge of the forces that have made our civilization what it is. Our social, economic, and political institutions are not mere accidents, but are the product of definite forces, the working of which is revealed on the pages of history. It is scarcely conceivable that citizens of one generation can function to fullest efficiency unless they have a fairly comprehensive grasp of the play of cause and effect back through the generations during which these institutions which condition their lives have been built. So I would submit this as the first criterion in the selection of subject matter for the students of whom we are thinking:—with no more non-essential detail than is necessary, to emphasize that we are where we are because of the long experience of the human race.

As a corollary of this proposition comes the second, namely, that the material selected should be as definitely as possible linked up with the life of today. The history major must learn much history for history's sake, but for the engineering student, we may take a more pragmatic view and teach history for the sake of the light it throws on present day problems. This generation of college students has a very keen, personal knowledge of the severe economic depression of the past several years, and of its effects on our individual and collective life. Because of the bitterness of their own suffering, students, and older people, are inclined to think of this as a unique and unprecedented experience and to do some unsound and unscientific thinking on the problems involved. The whole matter is seen in a much truer and saner perspective by those who know of the similar periods of the early 90's, the decade of the 70's, and that of the 30's of last century. The causes of these depressions can be discovered and the student can see that the operation of the same causes will doubtless produce similar results in time to come. While this historical

knowledge may not become general enough to lead to reforms that will forestall another such tragedy, yet for those who have it, such knowledge should help to prevent wild and irrational thinking about these fluctuations in the business cycle.

Current instances of corruption in political life, bribery, selfish lobbying, and venality on the part of public officials, all tend to disgust honest citizens and to cause them to lose faith in democracy, or to exercise an unbalanced judgment on men and measures of our day and generation, but one with even a casual acquaintance with history knows that such evil practices are not peculiar to his time, but have always been present in human affairs, regardless of the type of political organization that may exist, and that our republic has continued to live and make progress in spite of such facts. There is no case of bossism, of jobbery, of concession to vested interests, that cannot be more than matched in the records of the past. Such facts made to stand out in history study will not induce an attitude of callousness to evils in civic life, but will enable an enlightened citizenry to evaluate such incidents in current affairs with a balanced, rather than a distorted, judgment.

Such problems as the tariff, the relation of labor and capital, money and credit, government and business, foreign relations, war and peace, and a host of others which the electors of a government by the people must constantly be trying to solve, can be intelligently attacked only by citizens who can see these questions against the background of their historical development. So I would emphasize my belief that the interest of students who are in training to serve a democracy in technical engineering pursuits can be aroused by impressing upon them the practical value of a knowledge of the past because of the light which it throws on the issues on which they, as citizens, must pass judgment.

Again, an emphasis that will appeal to our students is that of the inevitability of change in an advancing society. The citizen who is ignorant, or unmindful, of this truth, as revealed by a study of human history, is prone to think of existing institutions as being more or less frozen into immutable forms. In the minds of such, proposals to revise fundamental laws, to reform the economic order, to amend the constitution, or to reconstitute the courts meet with undue and unintelligent opposition. The student of history knows that all the agencies of civil government, and of social and economic control, have arisen as reforms, or even as revolutionary changes, at some time in the past. He is, therefore, willing to study the proposed changes on their merits without panic in his thinking, knowing that a living society should not and cannot be held to outgrown forms by the dead hand of the past.

So much as to selection of material for emphasis. A few closing words as to the methods of presenting the subject. While the value of the study is enhanced by limiting the amount of material to be taught, yet the few facts selected should be well and thoroughly learned. Certainly no thinking in the field of the social sciences is of value unless it is based on sound knowledge of the facts underlying the given problem. Doubtless too much so-called thinking on political and economic matters is merely the expression of irritation or of prejudice, without relation to the historical background of the question. I have found that most students welcome frequent written tests calling for knowledge of definite factual material covered in class discussions and assigned reading. This involves a lot of work when classes are large. The easier way would be for the teacher to spend the semester lecturing, hoping that some seed might fall on fertile soil. I favor the more laborious method of definite concentration on a limited mass of subject matter, and the maintenance of as high a standard of mastery of that material as possible, with frequent tests to determine, for the student as well as for the instructor, how well the members of the class are assimilating the work presented.

If the class room discussions arouse interest, even engineering students can be stimulated to do some library reading in the field of history. If their attention is called to some interesting books dealing with topics that seem especially to appeal to the group, many will do considerable valuable reading. Without setting a specific amount of required library reading, but leaving that to the individual student's time and inclination, so long as each one does some reading in assigned areas of the course, I have had students report as much as five hundred to a thousand or more pages of such supplementary reading. The broader concepts so gained must be of value, and perhaps such an introduction to the literature of the subject may help to develop a habit of reading that will continue to enrich the life of the technically trained citizen.

Finally this group of students should have the subject of history presented in an interesting—even a dramatically interesting—manner. The history major, because of his inherent interest in the field, will dig into the dry and musty material, and will profit from even prosy and sleep-inducing lectures, but those whose special interest is in other lines of work have a right to demand that the dramatic story of human achievement in the realms of politics and nation-building, in agriculture and technology, in commerce and transportation, in social and cultural institutions, be dramatically presented. There is certainly a place in the class-room for the exact and ponderous methods of the history scholar, but there is also a place for the scintillating teacher of the type of Edwin

Earle Sparks. When an engineering student, speaking of the period of the history class, says, "That's one hour when I never look at my watch to see if it's about bell time," he is doubtless getting more of value from the course than he would get if he were listening to a more scholarly, but less inspiring, presentation.

May I express the hope that we who teach the social sciences may make them so valuable an item in the education of students in technical curricula that they will increasingly demand larger offerings in these fields; and that you, who have most to do with building and administering these curricula, may be sufficiently convinced of the need for more room for electives in social science and in other cultural and non-technical courses, that you may use your influence to broaden and liberalize your requirements. All his life the graduate from an engineering curriculum will be developing and deepening his knowledge and his skill in his technical field, but if he doesn't get these liberal courses while he is in college, he is not likely, in his busy professional life, ever to acquire the basic training in literary, historical, civic, and economic fields that marks the well-educated man and the efficient citizen of our republic.

VITALIZING INSTRUCTION IN ECONOMICS FOR ENGINEERING STUDENTS *

By WILFRED S. LAKE

Professor of Economics, Northeastern University

Replies to a questionnaire submitted to the students in my general course in economics this year revealed that the initial attitude toward the course was 18 per cent antagonistic, 27 per cent favorable, and 55 per cent neutral or indifferent. I suspect that these proportions are fairly representative after twelve years' experience with this course and after many discussions of my problems with other instructors in economics. From these figures the magnitude of the task confronting the teacher of economics to engineering students is clearly evident.

It would probably be of some interest to search for the explanation of this predominant lack of interest of engineering students in economics, but I prefer to accept the fact and to waste no time in trying to place the responsibility, some of which should undoubtedly fall on our own shoulders. Efforts to devise a constructive program to overcome this obstacle and to arouse strong interest in the course seem much more pertinent.

Many teachers turn first to the use of what we may classify for convenience as extrinsic interests, devices and techniques which have no necessary connection with the subject matter of the course. Probably the most common method is the attempt to arouse interest by making the classroom procedure entertaining, by "putting on a show." One of my former professors, who spent part of his sabbatical year in visiting economics classes in widely scattered colleges, found surprisingly prevalent an almost continual striving for laughs. This technique even appeared in print a few years ago in an introductory text by a well-known economist who admitted in the preface that he was guilty of "pretty poor wise cracking." He believed he was evoking more interest by labeling the demand curve as the "Dog-Cat line," the supply curve as the "Pig-Whistle line," and such illustrations as "a kiss is as good, as much as a piece of pie (often more, frequently less)." Such methods actually divert attention from the basic subject matter and encourage a flippant attitude on the part of the student. Humor, and other

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extrinsic interests, do have a legitimate use, but they must be employed sparingly, or they focus attention upon the instructor rather than upon the course.

While extrinsic interests have their place in aiding instructors to hold the attention of the class, it is undoubtedly wiser to place reliance primarily upon intrinsic interests, those which arise directly from the subject matter, or which unmistakably stimulate interest in the subject matter. A competent teacher should so conduct his course that a large proportion of his students will find themselves developing a real interest in economics as such.

Before much can be accomplished, however, the objectives of the course in general economics must be determined. I have little doubt that if most economics instructors were pressed for the specific aims of their course, the replies would be as vague and unsatisfactory as those given some years ago by Harvard instructors when a survey was made of their teaching methods. Hazy aims inhibit effective teaching and reflect themselves in student attitudes. Although I question the significance of the tabulation of 36 separate aims for the course in economics as cited by Lomax and Tonne in their otherwise excellent and suggestive work, "Problems of Teaching Economics," I do believe that a careful statement of basic objectives is extremely valuable. To me it seems clear that the aims should be: first, providing the student with certain knowledge about specific phases of our economic structure; and, second, training him in certain habits of economic analysis which will be permanently useful. After we decide what knowledge we wish our students to carry away and what habits of analysis they should develop, we can formulate procedures for developing intrinsic interest which will aid in attaining these objectives.

One of the most effective means of arousing intrinsic interest is the use of the daily newspaper, since the newspaper is a part of the environment of every student. Today no one can read the daily newspaper intelligently without a knowledge of the elements of economics. Even newspaper correspondents in Washington, according to a recent Social Science Research Council study, are convinced that a better foundation in economics would be of great aid to them in interpreting the significance of many governmental policies. Consequently, the use of the newspaper quickly reveals the value of economics to the student. One of the most frequent comments on the questionnaires I give to students every few years to check my own teaching is that the course has made them more thoughtful newspaper readers.

My personal practice is to follow the example of W. Z. Ripley at Harvard who, whenever possible, brought the morning newspaper to the class, and started his lecture by calling attention to

an item relating to a current topic in the course. This procedure is not easy, for the teaching program must be kept flexible, but I am convinced that the gain is great. Obviously this practice cannot be followed every day, but its effectiveness does not depend upon daily use.

Look over the possibilities of the last year. In reviewing my class notes I find such news items, a number of which coincided almost perfectly with my assignments, as: the change in bank reserve ratios, the wage and hour bill, certain cases of the National Labor Relations Board, the reciprocal trade agreement with Czecho-Slovakia (especially interesting for my students in a shoe manufacturing section), the petition of the Boston Consolidated Gas Company to increase rates, and the TVA controversy.

There are difficulties with such a technique. One cannot cover as much ground, but I hold that it is better to dig relatively deeply into a few topics and to illustrate habits of scientific approach to current economic issues, than to speed over a multitude of topics and fail to provide adequate motivation. This procedure trains the student in the proper approach under the same conditions which he will face later. Students who learn to ferret out the assumptions implicit in a proposal, and who seek the significant facts, are certainly profiting.

The instructor must guard against going into too much detail in his explanations, and must hold the discussion to the key issues, but this can be done. Also he must be cautious with controversial subjects. If dogmatic analyses and conclusions by the instructor and by students are banned, no real problem should arise. I prefer to insist that the student be able to make the analysis which he would expect the author of the textbook, as a representative economist, to make. The criteria furnished by the text must be utilized in this analysis, but the student is left the right to differ with the conclusion.

A second fertile source of intrinsic interest is to be found in the personal economic experiences of the students. In order to obtain as many such experiences as possible, I require my students to submit cases illustrating the operation of economic principles in their own background. In this respect I have some advantage over many instructors, for the coöperative plan at Northeastern means that my students have usually just returned to college from industry and have fresh experience behind them. However, this procedure can be used elsewhere, for many students work during the summer or have contact with industry through their fathers or relatives.

Over a period of years I have accumulated a large number of these cases which I use either as required collateral reading or as illustrative material for lectures. Throughout the course the stu-

dents are urged to introduce their experience into the class discussions. The testing by the personal experience of members of the class of the economic principles studied prevents the criticism that the course is too far removed from life. When I not infrequently discover students arguing about cases outside the classroom, I feel certain that their use is valuable.

This method also has its handicaps. It is impossible to cover all points by student experience, but this is not a crucial objection since the worth of the method does not hinge upon its universal application. In my supplementary textbook prepared from student cases, I have spread the coverage by including cases obtained from other sources. Again, such discussion takes time, but I justify it by the motivation furnished and the fact that the habit aims I seek are being furthered.

A third means for obtaining greater intrinsic interest is furnished by the careful selection of the subject matter of the course. I have yet to meet the teacher of economics who believes that he has found a thoroughly satisfactory textbook for engineering students. The traditional approach of most of the current textbooks too frequently tends to be academic in sections and repels the engineering student. Even those ostensibly designed primarily for engineering students make but a few concessions in the title, preface and in omissions which in one instance results in an incomplete theoretical framework.

For the present there is no solution other than selecting a textbook of established success from a teaching viewpoint, and then eliminating the undesirable chapters and sections. The instructor must bridge the gap in the theoretical structure in his lectures. Extended historical sections, excessively abstract treatments of the combination of the factors of production, and most of the material on economic rent may well be omitted. If those elements which have more apparent value to engineers are emphasized, much will be accomplished in arousing and maintaining interest.

Finally, the use of numerical problems is useful for students accustomed to problems in other courses. The exactness required minimizes the tendency toward hasty generalization and superficial reasoning. When such problems are not feasible, concrete problem situations with definite solutions, given certain criteria, may be substituted.

If these methods are used with a reasonable degree of success, I am confident that the initial indifference of engineering students can be overcome and that the fundamental objectives of the course in economics for engineering students will be more nearly realized.

CIVIL ENGINEERING PAGE

Notes of interest for members of the Civil Engineering Division.—Editor, M. W. FURR, *Kansas State, Manhattan*

F. T. MAVIS, *Chairman*
H. C. BIRD, *Past Chairman*
F. W. STUBBS, JR., *Secretary*
M. W. FURR, *Editor*
H. T. HEALD
PAUL P. RICE
HALE SUTHERLAND

SHOULD STRESSES IN STRUCTURES AND THE DESIGN THEREFORE BE TAUGHT AS ONE COORDINATE COURSE?

A discussion of the above topic constituted a part of one of the conference programs and was presented during the last annual meeting of the Society under the auspices of the Division's Committee on Structural Engineering.* A paper was prepared by Professor A. H. Fuller of Iowa State College; it was read by one of the members present. E. H. Gaylord, Professor of Civil Engineering, Ohio University, presided at the conference. Professor Fuller earnestly answered the question in the affirmative. His remarks, abridged by the *Editor,* were as follows:

In organizing a series of courses to include stress analysis and design and to follow mechanics, one is confronted by the question: what remains to be taught? In regard to types of structures, there are bridges, buildings, dams, retaining walls, tanks, transmission towers, cranes, etc.—in each one of these, many sub-divisions may be made. For bridges, the material may be steel, concrete, timber or other substances, and the service may be for highway, railway or industrial purposes. The structure may be statically determinate or statically indeterminate and may consist of simple trusses, continuous, cantilever or suspension spans, or arches of various types.

The problem of the teacher is to select the necessary fundamentals, the really basic principles, and to so present them that the student may be depended upon to extend his brief class room experience and knowledge of materials and mechanics into a field that is rather imperceptible to undergraduate engineers. No attempt should be made in college to present all of the aspects of the subject that are commonplace to the "seasoned" engineer. The extent of use of steel Handbooks to be allowed or encouraged is a matter to be decided upon in the student's interest. The beam and column frame, the roof truss, the plate girder and the through simple truss bridge have served long and well as vehicles for both stress analysis and design. Each of these structures has its merits in a coördinated course of study.

The beam and column frame may be made an effective connecting link between strength of materials and structural design. A brief review of the principles of beam action and the use of column formulas lead naturally to the relative dimensions of the beam and the column and the connections of one to the other. A roof truss offers an excellent opportunity for graphical

* For additional papers of this conference refer to the *C. E. Bulletin* for May, 1939.

analysis of stresses, with adequate algebraic checks. It also offers great possibilities for the discussion of the loads (dead, snow and wind) which a roof and a building must be able to carry, not to mention but briefly the value in making a choice of the dimensions and proportions of the structure and the coördination of all the various factors. The final interest and value to the student comes when he is able, rather soon, to decide upon a possible truss, purlin and roof layout, compute the stresses and design the necessary members and their connections. Reference to specifications may well be confined to loads and unit stresses. Limited discussion of shop practices and detail standards may be introduced and where feasible supplemented by a visit to a fabricating plant and to nearby structures. Likewise the plate girder and simple trusses each has merits when stress analysis and design are combined into one course. In the latter case the influence table may be very advantageously used. It is easy to understand and to use. Each stress computation is for one load (a unit load) in a definite position. The influence table also forms the basis for analysis of positions of panel loads for maximum and minimum live load stresses which is an effective way of teaching the determination of positions and the computation of stresses in simple trusses without the further use of the influence table. It is particularly important because it takes the mystery out of complicated trusses whether statically determinate or not by reducing each computation to that for a single load.

The use of influence table presentation of stress analysis for live loads is not in itself an argument for a combined course in analysis and design, yet it lends itself nicely to such a course. Stress analysis is not an end in itself but is a means for securing some of the necessary information for design and is eventually more thoroughly understood and appreciated when judiciously mixed with design. Why not apply, directly to a structure, one of the first, perhaps *the* first, complete combination of dead, live, impact and wind stresses which the student makes.

A large part of design consists of applying the various provisions of the specifications to the selection of loads, unit stresses, and individual members and to the fitting together of individual members into an effective structure. The student may readily be taught the mechanics of such things as the design of compression members and the net section of tension members. The student will not readily absorb an understanding of the many provisions of specifications nor have the judgment for creating a structure. Therefore, rather than attempt all of these matters at once in a design course (which might of necessity be separated from analysis because of length), Professor Fuller prefers, before spending much time on advanced analysis, to acquaint the student with the specifications and to begin to build up judgment on design by reviewing a well designed structure, preferably by a specification other than the one under which it was designed. As the weights, stresses, sections and details are checked, excellent opportunities are presented for discussing the mechanics, the bearing of the specifications, and the philosophy of design. To the frequent question of the student: "Why did the designer do this or that," a reply which is well for the teacher to put is: "What would you have done in the same situation?" This procedure in teaching stimulates analytical thinking on the part of the student.

Creative design mixed with stress analysis is a natural combination for statically indeterminate framed structures. Such a combination is particularly effective after a review of a design and a fairly good appreciation of the bearing of specifications upon a design. The approximate design, or designs, which must precede a final selection of sections gives experience in

proportioning a structure in such a manner as to serve as an effective review of both stress analysis and design.

The rigid frame type of structure, which now commands consideration is not likely to be carried to the design stage in an undergraduate course, but the exposure to curved beam theory, slope deflection, and moment distribution by students who have been trained to think and to extend their frontiers will bring results in graduate work and in practice.

Now to return to the question: *What principles are really basic?* The beam and column frame, the roof truss, the plate girder, the truss bridge and the statically indeterminate framed structure have been analyzed for stresses and have been designed (or a design has been reviewed) by rather simple and natural extension of principles in mechanics rather than by the introduction of many new principles or concepts.

The computation of stresses, whether by algebraic or graphic procedures, have been direct and simple; nothing new in principle. The analyses of results have required only simple logic and common sense; nothing new in principle unless perhaps the word "principle" should be used for the deduced fact that, in a simple framed structure when a section cuts a web member (and two chords), all loads on one side of the section produce stress of one character in the web member while loads on the other side produce stress of the opposite character.

The analysis and design of steel structures require certain "concepts and procedures" instead of "basic principles" in order to bring together the tools and guides which are most essential in structural analysis and design. The independent principles and concepts are: the conditions of static equilibrium; Hooke's law; the definition of modulus of elasticity; the definition of work; and the assumption that, in a beam, a plane section before flexure remains a plane. The others are all derived from these or are adapted from practice.

In an undergraduate course, we are not concerned with elaborate discussions of such matters as the basic unit stress, the relation between the unit stresses for tension and shear, the compression formula, combined stresses, stiffener spacing, loads, and workmanship except to introduce the philosophy which has led to the specification and to recognize each portion of the specification, not as perfect or permanent, but as representing the best of present composite engineering judgment whether in class room, office or in a court of law.

ENGINEERING ECONOMY PAGE

Engineering economy is that phase of engineering work in which technical plans and operations meet the critical and constructive tests of applied economics.

EDMUND D. AYRES, University of Wisconsin, *Editor*

ENGINEERING ECONOMY CONTENT OF NEW YORK STATE LICENSING EXAMINATIONS

In writing about the course described below Professor Barnwell tells us that quite a large proportion of the questions used to date in the Economic Division of the New York State examinations for the licensing of professional engineers hinge on engineering enonomics as treated in E. L. Grant's "Principles of Engineering Economy." He comments upon a set of such examination questions which he has compiled in mimeographed form as having a "heavy weighting of problems based on Grant's 'Problems of Engineering Economics.'" He further remarks, "In more recent examinations, particularly the one offered in January of this year, there seems to be some tendency to get away from this."

The New York examinations are given semi-annually and the applicant for a license is allowed to take any material into the examination that he cares to and to make free use of it during the examination.

PROFESSOR BARNWELL CONDUCTS A. S. M. E.—A. I. E. E. SPONSORED LECTURES FOR NEW YORK STATE LICENSE CANDIDATES

The American Society of Mechanical Engineers and the American Institute of Electrical Engineers are jointly sponsoring a series of lectures—some 18 in number—with the view of coaching their members in preparation for the New York State Examination for the licensing of professional engineers. This course is conducted by Professor George W. Barnwell of Stevens Institute of Technology, Hoboken, New Jersey. The content of the course is based directly upon the questions which have been asked in the Economic Division of the examinations over the last several years. The broad divisions of the course follow:

1. The Business Cycle as It Affects the Engineer.
2. Business Organization and Finance.
3. Financial Mathematics.
4. Economic Selection and Replacement Studies.
5. Valuation and Appraisal—Depreciation Theory and Practice.
6. Business Law in its Application to Engineering Contracts.
7. Professional Practice.
8. Professional Ethics.

Professor Barnwell advises his class (enrollment of thirty-five to forty) to obtain a copy of Professor Grant's book for use as a general text and issues a reading list for guidance in covering the topics beyond the bounds of engineering economy.

Solutions of the problems given to date and brief answers to the other questions have been mimeographed. These notes are sold at cost to those desiring them. Ready reference to these notes saves time which would otherwise be consumed in working out all these problems and questions in class. Later an outline treatment, probably a hundred pages in all, will be mimeographed as a further aid to those members of the societies who are unable to attend the lectures in New York City.

ENGLISH NOTES

DEVOTED TO THE INTERESTS OF TEACHERS
OF ENGLISH IN ENGINEERING SCHOOLS

J. L. VAUGHAN, *Editor*, University of Virginia

LITERATURE IN THE ENGINEERING COLLEGE*

By J. L. VAUGHAN

I

Recently there have been two comprehensive surveys of the amount and type of English taught in engineering colleges. The authors of both studies have compiled statistics which show that more time is devoted to literature than to any other English course in the engineering curriculum except elementary composition.† Since these surveys supply all necessary data for those interested in the place and importance of literature in technical schools, this chapter will be confined to a discussion of opinions on the subject as gathered by the English Committee.

Replies, in answer to this Committee's inquiries, seem to indicate that most of those concerned with technical education favor including literature in the engineering curriculum. Of 242 people who replied, 196 commend its teaching; 23 emphasize that it is not so important as speech and composition, and 23 think that it may be omitted from the course of study. Although these figures were

* This is chapter III of the English Committee's report on English in engineering schools. J. L. Vaughan is Head of the School of English in the Department of Engineering at the University of Virginia.

† Creek, H. L. and McKee, J. H.—"English in Colleges of Engineering," *The English Journal*, Vol. XXI, 1932, pp. 818–828. Fountain, A. M.—*A Study of Courses in Technical Writing*, Bulletin No. 15, Engineering Experiment Station, North Carolina State College, Raleigh, N. C., May 1938. On page 49 of his recent book, Professor Fountain gives the following statistics: "The average requirement of English courses for engineering students in all the 117 institutions [the study was based on the curricula of the 117 institutional members of the S. P. E. E.] is 13.8 quarter-hours, apportioned as follows: elementary composition, 7.40 quarter-hours; literature, 2.75 quarter-hours; technical writing, 1.40 quarter-hours; public speaking, 1.20 quarter-hours; advanced composition, 0.59 quarter-hours; business English, 0.11 quarter-hours; journalism, 0.03 quarter-hours."

not systematically gathered, they seem to show that the majority of the group which answered the inquiry thinks literature should be taught in the engineering college.

Some representative statements by engineering educators may be quoted to show why literature courses are approved. Karl T. Compton of the Massachusetts Institute of Technology states: "As a cultural study it [literature] should broaden the engineering student's acquaintance with the best thought in fields of human interest not specifically related to his professional work." Franklin Thomas of the California Institute of Technology observes that every engineer needs a course in literature "to enrich his life, and to enable him to associate on a comparable basis with other college trained men." F. E. Ayer of the University of Akron remarks that literature should be taught "better to enable the engineer to enjoy his spare time." H. P. Hammond of the Pennsylvania State College also recommends literature courses because they enable a student to form good reading habits and, indirectly, to develop a clear, or even elegant, style.

In the opinion of graduates there are numerous reasons for studying literature. G. A. Peacock says: "Particularly in the mining profession, where years on end may be spent by the engineer in so called 'jungle camps' whose society dissects the graduate for his social assets, both literature and speech are primary requirements to his success. Hence the importance of English in an engineering school cannot be lightly spurned." M. L. Hurni remarks: "I feel that interpretative courses in literature are exceedingly important—a bit of Wilder's gentle melancholy, some of Nietzche's violent pessimism, a few of Anatole France's sharp barbs, a little of Galsworthy's brutal realism, and certainly a purgative dose of G. B. Shaw, each with ample footnotes. . . ." According to R. J. Exter, literature should be taught because "engineers should aspire to higher positions (executive) where a fair cultural background is expected." And Clayton Wright suggests that literature is desirable because it will "prod" a student into "forming good reading habits. . . ."

Some of the personnel men make interesting observations on the importance of literature. Dennis O'Harrow of the State Planning Board of Indiana writes: "The engineering graduate should have a basic knowledge of literature that will enable him to meet members of the other professions as a cultural equal, not as a transplanted stevedore." E. M. Billings of the Eastman Kodak Company states: "It is generally agreed that the study of good literature is valuable as a broadening influence and as a contributing factor in improving the engineer's vocabulary and skill of expression. . . ." W. R. Allen of L. S. Ayres and Company tells the

following anecdote to show why literature is important to the practicing engineer: "Perhaps you heard me say . . . that my father, while traveling in India a number of years ago, met some English engineers who were putting up a bridge in northern India. He asked why they did not use American engineers, and they very promptly said that while American engineers were undoubtedly the highest trained men in the world they were no fun on a job which required only four or five hours' work a day, due to the heat. Much of their time in distant countries was involved in leisure, where men played games like chess, read poetry, and talked on the philosophers. American engineers who did not have such a background were distinct liabilities when far away from home. In short, they were no fun because they were not cultured."

The consensus is that literature should be studied because it (1) teaches a student to read with understanding, appreciation, and enjoyment; (2) broadens his intellectual horizon and breaks the stranglehold of the present; (3) helps him to use his leisure time to greater advantage; (4) encourages him to form good reading habits and develop a clear, even elegant, style; and (5) enables him to attain an acceptable cultural level.

There must not be overlooked, however, the opinions of a minority group disagreeing with these conclusions. The case for those who do not regard literature as particularly important is presented by E. B. Norris of the Virginia Polytechnic Institute who says: "I do not believe that courses in literature as such are worth the time devoted to them, certainly not when the material used is of the usual type. Appreciation of literary quality must first be preceded by an interest in the subject matter, lacking which such courses are lifeless and useless. There is real literary merit in many scientific and engineering documents but try to convince an English teacher of that fact!" Dean Norris suggests more emphasis on grammar, spelling, punctuation, and composition and the "elimination of any attempt to teach 'literature,' the accomplishment in which is at least doubtful, if not wholly negligible."

Others in this group mention problems which worry them and make them wonder whether literature, as taught, is worth the time devoted to it. For instance, Thorndike Saville of New York University finds that the English professors do not agree with him on the type of literature which should be taught to engineering students. "We believe that one cannot and should not expect a student of scientific temperament to become enthusiastic over the literary classics which would appeal to a student majoring in English literature. On the other hand, there are many literary classics which would appeal to a student of scientific temperament, but it has been our experience that English instructors have on more than

one occasion actually gone out of their way to prevent a student from reading such books as Huxley's 'Man's Place in Nature.'" At the risk of digressing, the writer wishes to point out that administrative officers seem to be encountering most of their problems because they cannot agree with the English professors on the type of material to be used in the literature course. Many of the deans do not object so much to literature as to the way in which it is taught.

Some graduates are also convinced that literature is unnecessary. G. W. Hintgen observes: "The high schools give the engineering student enough English literature without being forced into more!" David Clark remarks: "I do not feel that instruction in literature is important." And P. A. Washer says that it "would be better to concentrate on composition and on speaking rather than to consume time in the study of literature."

M. J. Maiers of the Commonwealth Edison Company speaks for the personnel men who do not recommend the teaching of literature: "I . . . have a faint suspicion that the young men selecting engineering do so, in some measure at least, to get away from the English literature. To include any appreciable amount of literature in an engineering course might cause this group to look for other fields where literature is less dominant." John F. Luhrs of the Bailey Motor Company makes the interesting point that, although the engineering student needs a broader training, literature does not offer a satisfactory medium.

From the preceding comments, it is obvious that a minority does not favor the teaching of literature in the engineering school. It objects to including the subject in the curriculum for the following reasons: (1) literature courses, as such, are not worth the time devoted to them; (2) engineers and teachers of English disagree on the type of literature to be taught; (3) students with a scientific turn of mind have little interest in literature.

In some of the replies from the engineering educators, engineers, personnel men, and recent graduates there are suggestions as to the kind of course in literature for technical students. W. P. Graham of Syracuse University epitomizes the opinions of many in the group when he states: "Whether the study of literature is effective depends upon how it is taught. If the approach is *critical*, the engineering student is not likely to derive much benefit from it. If it is *inspirational*, the student is likely to be interested and to benefit. If he gets a glimpse of literature as reflecting contemporary 'race philosophy' at different epochs, he is likely to acquire habits of thought which will be of value to him all through life." W. S. Rodman of the University of Virginia believes that literature should be taught but that the course should be so arranged as to

present "outstanding writers rather than to subject engineering students to the usual type of survey which attempts to span the entire fields of English and American literature." R. C. Disque of Drexel Institute criticizes the courses now offered because the "prescribed readings . . . include too many things in which the student has very little interest." C. A. Dykstra of the University of Wisconsin suggests that above everything else the course in literature should teach engineering students to read well.

Several of those who expressed opinions on this point are in favor of including material that stresses the engineering approach. J. A. Bradley of the Newark College of Engineering says: "I do not feel that the study of classical English literature is desirable in an engineering school. It has been tried at the Newark College of Engineering and abandoned in favor of work more pertinent to the development and culture of the engineer. It has been replaced in the oral presentation of short papers, in the more systematized practice of writing, in the reading of selections dealing with the history of science and engineering, and by a course in the History of Industrial Civilization." And Samuel W. Bradley of Yale University thinks that "reading should be varied enough to stimulate an interest in social and economic problems as they relate to engineering."

In the same vein are statements of recent graduates. Henry Escher, Jr., writes: "In the matter of literature, I feel strongly against any attempts to instill in engineering students an ability to criticize and analyze academically what they read. . . . If an engineer never learns the difference between iambic pentameter and trochaic trimeter, he probably will not suffer very much. . . . If an engineering school English department gives some training in reading, together with an opportunity to read broadly, I think nothing more can be expected of it in the matter of literature study." H. M. Peterson adds: "It is my contention that there is sufficient good literature dealing with engineering subjects to write a course which would be interesting and informative to the student."

These representative quotations illustrate the ideas of a majority of engineers and engineering educators about the best type of literature course for engineers. Their opinions may be summarized as follows: (1) Literature courses in an engineering school should be general and inspirational rather than critical. (2) A careful selection from the best writers is better than a narrowly specialized course in one type or period. (3) Engineering students will probably read more if the course in literature emphasizes material chosen from science and engineering. (4) The aim of every literature course should be to teach the student to *read* in the broadest meaning of the word.

II

In the preceding section there were summarized the opinions of administrative officers in technical colleges and of engineers. This section will present the views of those who teach literature to engineering students.

Some professors of English are inclined to believe that they would be more successful if they could obtain the coöperation of their colleagues on the technical staff. For example, Robert M. Smith of Lehigh University says: "We need heads of engineering departments who are willing to give English and speech departments ample time for this work." And G. F. Taylor of Tulane University adds: "Despite enthusiastic . . . endorsement of the work in English by most of the influential members of the engineering staff, students continually find themselves under such heavy burdens of strictly technical work that they are indirectly encouraged to slight their work in English. . . . Although this does not necessitate any lowering of our standards . . . it does mean that a larger number of men do mediocre or grudging work. . . ."

Other professors, however, report the full coöperation of members of the engineering staff. C. F. Judy of the California Institute of Technology states that "all the effort [of the Department of Humanistic Studies] is well supported by the trustees and faculty of the Institute." C. H. Barnwell of the University of Alabama says: "The relation between the department of English and the college of engineering has always been very cordial." The writer, who is in charge of the School of English in the Department of Engineering at the University of Virginia, can also praise his colleagues for their coöperation; he believes that they really teach the English in the department because they emphasize the importance of the subject.

Apparently in some quarters there is little coöperation between the English and the technical staffs, while in others the two groups seem to have arrived at a satisfactory solution of their problems. Those who are having difficulty complain that the technical staff overloads the students with engineering work and does not allot sufficient time in the schedule to the humanities. Those who have made some progress toward solving their problem commend their engineering colleagues for lending ungrudging aid.

Some of the instructors in English think that engineering students do not ordinarily have much interest in literature. Sharon Brown of Brown University states: "Work in English literature is distinctly secondary. . . . Though it may seem a sweeping generalization, it is true that the scientific type of mind does not respond to the study of literature." C. W. Wilkinson of the Agricul-

tural and Mechanical College of Texas declares: "If I try to teach literature or anything other than a 'practical' course—one the students think offers them immediate returns in dollars and cents—I always feel that I am trying to cram an unpalatable something into a squeamish stomach."

Other professors have had a different experience with scientific students, as their comments show: S. F. Pattison of the University of Arizona remarks: "My experience has been that the engineers are well above the average in their literature interest." T. D. Bowman of the Pennsylvania State College observes: "In this field I have found the scientific student less responsive than the undergraduate specialist in English but somewhat more responsive than the average liberal arts or commerce and finance student encountered in the conventional survey course."

Also, it would seem, there are divergent opinions among the teachers of English who answered the English Committee's inquiry. One group finds that the student with the so-called "scientific mind" has little interest in literature; the other believes that he has as much interest in literature as the average student of liberal arts and of business courses.

It seems appropriate at this point in the discussion to examine the type of literature course now offered in technical schools. A study of the replies to the English Committee's letters of inquiry shows that of the 38 professors who mentioned the kind of literature courses they teach, 20 offer a survey and 18 teach a new type of work in literature which seems to them more adequately to meet the needs of the engineering students.

The following are representative statements by those who favor the survey course. T. D. Bowman of the Pennsylvania State College says: "I do not believe special types of courses in literature are necessary for engineering students." R. E. Clark of the Agricultural and Mechanical College of Texas observes: "Survey courses at the sophomore level seem to me to call for no more specialized treatment than for the non-engineer." And Donovan Pratt of Purdue University recommends, wherever practicable, more generalized rather than more specialized work in literature.

There are other teachers of English, however, who are not in favor of the conventional survey course. S. M. Tucker of the Polytechnic Institute of Brooklyn regards the "general survey course in English as an utter waste of time." William Braswell of Purdue University states: "I should not advise survey courses but those in which a few masterpieces are studied." Alexander Buchan of Washington University adds: "The history of literature has been tried, and abandoned, as being nauseating to the students." W. F. Scamman of the University of Maine feels that too many students

are driven away from literature by "traditional formalized courses." From the statements given above, it is evident that some instructors have found the survey course in literature unsatisfactory for engineering students.

Courses which have been substituted for the survey are: (1) combination of history and literature; (2) great masterpieces; (3) modern literature and contemporary problems; (4) humanities with emphasis on wide reading.

Jesse R. Morgan of the Colorado School of Mines offers a combination course of literature and history; his main object is to give the student a "better understanding of literature and a sense of world values in society." P. B. McDonald of New York University says: "In our college teaching of literature and cultural backgrounds, we have found biography and fiction more popular than essays, poetry, and drama. A great deal of history has to be incorporated in such courses."

Several of the professors are now teaching a course in great masterpieces of the language instead of attempting in a survey to cover the whole field of English or American literature. S. M. Tucker of the Polytechnic Institute of Brooklyn outlines the objectives of the courses as taught in his department: "At the Polytechnic Institute of Brooklyn, the professors attempt to introduce the students to the masterpieces in the language: plays, short stories, and biographies are introduced into the sophomore reading course. Meticulous analysis is avoided; the purpose is to encourage students to read as widely as possible." Next year S. F. Pattison of the University of Arizona expects to teach a course in which he will deal with literary masterpieces. He hopes to stimulate interest in great literature by showing students the pleasure that may be derived from reading good books.

At some institutions the instructor in English has found that a course in modern literature and contemporary problems is preferable to the conventional type of survey. For example, J. W. Barley of the University of Missouri offers courses in modern literature both English and American with emphasis on "literature as a product and a record of society rather than as esthetics." W. F. Scamman of the University of Maine gives "Modern Literature" which is designed to "acquaint the student with contemporary literature, to give him an understanding of contemporary thought or philosophy, and to develop appreciation (in the sense of standards of evaluation) of literature." Arthur W. Peach of Norwich University uses the same type of course to give the student "some insight into the cultural forces of his day." G. D. Haefner of the Webb Institute of Naval Architecture remarks: "We attempt to give our students a deepened appreciation of the best in literature

and to enable them to use such literature as a means of relating their work to the problems of life. . . . So far as the subject matter permits, these discussions [discussions are held in class] concentrate upon the important psychological, economic, and social problems which underlie the literary examples." It will be observed that these courses serve a dual purpose; to teach modern literature and to introduce the student to some of the problems of the modern world.

In several engineering schools the humanities course has replaced the survey. At Union College, Burgess Johnson and his colleagues are now teaching a band of liberal courses "extending through the four years of engineering education and providing one course each year. . . . Required reading has for its purpose acquaintance with good books that are significant in the life of today; and practical efforts are made to start students in the setting up of their own individual libraries." Amy V. Hall of the University of Washington has fashioned a course which attempts to acquaint the student with a "broad outline of man's knowledge." The English department assumes "responsibility for introducing technical students to the four broad fields of human knowledge: (*a*) The Physical Environment: the earth, astronomically and geologically; forces now active. (*b*) The Biological Environment: life, plant and animal; Man, from the standpoint of anthropology and of spychology. (*c*) The Social Environment: human institutions. (*d*) The Cultural Environment: ideas of leaders in art, literature, and philosophy." Apparently some teachers of English in engineering schools have abandoned the survey course and are now emphasizing the humanities as a whole instead of English or American literature.

The preceding paragraphs have recorded some typical instances of teachers who have abandoned the traditional survey and developed courses more suitable to the needs of their particular departments. Out of these experiments there may arise a new kind of course which will be satisfactory both to engineers and to English professors. If not, these pioneers will at least deserve the praise of their colleagues for having attempted to teach English in a new and a stimulating way.

Methods used by professors of English to encourage engineering students to read can receive only brief mention here; and that is regrettable, for many of them are interesting.

In one institution, the professors of English, recognizing that engineering students have little time to read during the winter, have arranged a course entitled "Summer Reading." The English staff supplies a list of acceptable books from which the student may read during the summer vacation. In the autumn if he sub-

mits satisfactory reports, he receives elective credit for the summer's reading. In another engineering school, the instructors permit a student to compile a bibliography on a subject in which he is interested. Once an acceptable list has been made, the student begins reading and continues until he has finished the necessary books. Then he reports his findings and is given elective credit if he shows a grasp of the material covered. Another professor encourages students to read by inviting prominent people to talk to the class on "Books I Read for Pleasure." Often students will choose their parallel reading from the titles mentioned in these discussions. At another institution, an alumnus has come to the aid of the English teachers by offering a hundred dollar prize to the senior making the best collection of books for a personal library during his four years in school. These are only a few of the methods which are being tried by alert teachers of English in engineering schools, but these are sufficient to prove that some professors have accepted the challenge and are bringing imagination and enthusiasm to their task.

III

From the representative opinions of engineering educators, of practicing engineers, of personnel men, and of recent graduates, a majority is found in favor of teaching literature in the technical school. These groups believe that such a course enables a student to read with appreciation and with understanding, broadens his intellectual horizon, and helps him attain an acceptable cultural level. There is a minority group who do not consider literature important. The engineers are also convinced that literature courses should be inspirational and should serve as an introduction to the humanities; in their judgment, English teachers often miss the mark because they become too analytical and too specialized.

The English instructors disagree on the amount of interest the engineering student has in literature. Some believe that he responds as readily as does the average college student who is not specializing in English; others think that he is too interested in the sciences to pay much attention to literature.

There is no agreement among the English teachers concerning the amount of coöperation they receive from the technical staff. One group thinks the engineering faculty could be of more assistance; the other commends the engineering staff for giving all the aid that could reasonably be expected.

In the statements of the English professors there also appears a disagreement as to the type of course which should be offered. Some continue to teach the traditional survey, and others offer new

courses which seem to them more adequately to meet the needs of their students.

The one significant conclusion which can be drawn from the material gathered by the Committee is that most of the engineers and most of the English teachers, though they disagree at points, are convinced that the graduate of an engineering school should have both adequate technical information and an appreciation of the part that literature can play in the life of an educated man. Both groups are almost unanimous in their opinion that literature must be included in the engineering curriculum.

MATHEMATICS DIVISION

At the Kansas-Nebraska regional meeting of the S. P. E. E., held at the University of Nebraska, October 21–22, 1938, the Mathematics Division presented the following program:

1. Entrance Deficiency in Mathematics of Engineering Freshmen and Remedial Measures. Prof. J. P. Colbert.
2. Inequalities for Preparation of Freshmen in the College of Engineering. Prof. W. C. Brenke.
3. Bessel Functions and their Applications to Engineering Problems. Dr. D. T. Sigley.
4. A Short Course in Selected Topics for Engineering Students. Dr. H. E. Jordan.
5. Statistics Applied to Engineering Problem. Prof. A. E. White.

Professor Colbert gave a report showing that at the University of Nebraska for the past 5 years there were 13, 12, 14, 14, 16 per cent of the classes deficient in algebra.

Professor Brenke presented the results of some qualifying tests given to prospective engineers and some others. These tests showed the following.

	Range of Class Average
1. 47 schools	100–72.3%
2. 51 schools	71.4–55.0%
3. 46 schools	53.8–37.5%
4. 46 schools	37.0– 0 %

Obviously there is a difference in preparation when, on the same test, the average grade of students in one school is 95 per cent and in another 15 per cent.

Dr. Sigley discussed a recent paper by William Murray on Heat Dissipation through an Annual Disc or Fire of Uniform Thickness as an illustration of the use of Bessel Functions in the solutions of engineering problems.

Professor Jordan stated that a three-hour course in selected topics for engineering students given at the University of Kansas contained the following: Solution of Equations by the Method of Iteration, Nomographic Charts, Empirical Equations, Interpolation, Graphical Differentiation and Integration, Hyperbolic Functions, Harmonic Analysis.

Professor White indicated how various elementary statistical methods such as use of arithmetic means, standard deviation, normal curve, curve fitting, and correlation could be of considerable use to engineering students.

THE T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE
DIVISION OF ENGINEERING DRAWING

F. M. PORTER, *Editor*, University of Illinois

DESCRIPTIVE GEOMETRY AS A TRAINING IN THINKING

Those who formulate the engineering curricula of today retain descriptive geometry in spite of occasional clamor that it be eliminated as a waste of time. In some instances it has been reinstated after a brief period of removal. What is the proper valuation of it as a subject which consumes, in general, about three per cent of the total curricular time?

Most engineering educators agree that it develops a convenient practical skill quite akin to that of drawing, some deeming it little more than the theory underlying projective drawing. If it were nothing more than this, making possible the construction of designs which otherwise would be beyond the ability of the average draftsman, its place in the curriculum would be justified. But its real value far transcends this merely utilitarian usage. It is a means of training the engineer in the habit of exact thinking which his profession demands.

The term "analysis" as employed in the study of descriptive geometry has a closely defined meaning quite the same as when used by the chemist, lawyer, and engineer—that of a critical examination of all available evidence or data, from the result of which is formulated a scheme of procedure which effects a successful solution. The doctor, when confronted with a new situation, reasons in a similar way in making his diagnosis, and in nearly every human experience which requires conscious reasoning, the thought processes, if effective, follow such an order.

Not only in professional work is it desirable to think in a logical and orderly manner. In every walk of life, when one meets a new set of puzzling or baffling facts, there must be a concentration of effort to construct an analysis in the light of one's knowledge of the laws or rules which pertain to such a circumstance. Only thus can a wise decision be reached as to the most effective method of dealing with the facts. This is precisely the kind of attack which the study of descriptive geometry encourages. While this sort of training in thinking is desirable for all, it is indispensable for the engineer.

The study of descriptive geometry is a most efficient course in logic. Dealing as it does with concrete geometrical forms, the concepts employed in all discussions may be made sharp and real. Too often in the formal courses in logic there is a haziness which hides the syllogism, largely because of the abstractness of most of the terms involved. For this reason it is impossible to obtain clarity of verbal statement from the student, since sharply focused expression can never come from fuzzy thinking. Put in another way, expression is a definite index which shows whether or not clear and constructive thinking has been attained. By careful and persistent effort, on the part of teacher and student alike, descriptive geometry may be made a beautifully exact vehicle of both thinking and expression in words. For this reason it is worthy of its modest place in the engineering curriculum and would be a valuable addition to every college course.

NEW MEMBERS

Associate Institutional Membership:
EASTERN NEW MEXICO JUNIOR COLLEGE, Portales, New Mexico.

BARTLETT, HOWARD R., Acting Head, English and History, Massachusetts Institute of Technology, Cambridge, Mass. R. D. Douglass, S. D. Zeldin.

BOGARD, BEN T., Assistant Professor of Mechanical Engineering, Louisiana Polytechnic Institute, Ruston, La. E. C. Barrett, R. T. Sessums.

BUCHAN, ALEXANDER M., Assistant Professor of English, Washington University, St. Louis, Mo. A. S. Langsdorf, E. O. Sweetser.

CLARKE, CLARENCE L., Acting Co-Director; Dean, Liberal Arts, Professor of Education, Lewis Institute, Chicago, Ill. F. A. Rogers, L. C. Sherman.

GRAVES, QUINTIN B., Instructor in Civil Engineering, University of Texas, Austin, Texas. Leland Barclay, P. M. Ferguson.

HENRY, HOWARD J., Instructor in Mechanical Engineering, University of Kansas, Lawrence, Kansas. Ralph S. Tait, Earl D. Hay.

MCFARLAND, REGINALD A., Professor of Civil Engineering, Louisiana Polytechnic Institute, Ruston, La. R. T. Sessums, E. C. Barrett.

MCQUIRE, JOHN G., Instructor in Engineering Drawing, A. & M. College of Texas, College Station, Texas. B. F. K. Mullins, C. H. Ransdell.

MERRILL, DONALD W., Instructor in Drawing and Architecture, University of Arkansas, Fayetteville, Ark. B. N. Wilson, G. P. Stocker.

MILES, JOHN C., Instructor in Mechanical Engineering, University of Illinois, Urbana, Ill. J. R. Fellows, W. H. Severns.

MITCHELL, WILLIAM L., Professor of Mechanical Engineering, Dean of Men, Louisiana Polytechnic Institute, Ruston, La. E. C. Barrett, R. T. Sessums.

NETHHEN, HARLEY J., Professor of Electrical Engineering, Louisiana Polytechnic Institute, Ruston, La. E. C. Barrett, R. T. Sessums.

PETTYJOHN, ELMORE S., Assistant Professor of Chemical Engineering, University of Michigan, Ann Arbor, Mich. A. H. White, E. M. Baker.

RIKER, CHARLES R., Editor, *The Electrical Journal*, 101 Woodhaven Drive, Pittsburgh, Pa. Chas. F. Scott, F. L. Bishop.

STACE, F. N., Editor, *New Zealand Electrical Journal*, P. O. Box 1572, Wellington, C.1, N. Z. F. L. Bishop, Nell McKenry.

WILHELM, ERNEST J., Assistant Professor of Chemical Engineering, University of Notre Dame, Notre Dame, Ind. R. E. Rich, G. F. Hennion.

WOODMAN, LONGINO A., Instructor in Civil Engineering, Louisiana Polytechnic Institute, Ruston, La. R. T. Sessums, E. C. Barrett.

WYNN, ROBERT S., Associate Professor of Electrical Engineering, Louisiana Polytechnic Institute, Ruston, La. E. C. Barrett, R. T. Sessums.

COLLEGE NOTES

The Missouri Regional Conference for Surveying Teachers and Practicing Engineers held under the auspices of Committee Eight of the Civil Engineering Division of the Society for the Promotion of Engineering Education was held at the Missouri School of Mines and Metallurgy at Rolla on April 6, 7 and 8.

The meeting was arranged under the general chairmanship of Professor E. W. Carlton of the Missouri School of Mines and Metallurgy. The purpose of the meeting, according to Professor Carlton, was to discuss the various problems confronting surveying today. This particular program stressed in one of its general sessions present day teaching and course content in courses in surveying commonly given in engineering schools. The teacher, the practicing engineer and representatives of governmental agencies had a chance to discuss these problems with mutual benefit. This permitted the teacher to get the angles of the practicing engineer and governmental agencies who specialize in large surveying projects and to gather ideas for teaching and improvement of present day surveying courses.

A total of thirteen papers were read and discussed at the conference. There were seventeen states and the District of Columbia represented with delegates. There were nine commercial organizations represented; ten governmental organizations and fourteen educational institutions. The total attendance at the conference was one-hundred and seven.

University of Minnesota.—The U. S. Bureau of Mines first aid and mine rescue staff under the direction of A. J. Stromquist, principal safety instructor, will conduct first aid and mine rescue classes at the School of Mines and Metallurgy, University of Minnesota, for a period of three weeks beginning April 10, 1939. Professor John D. Akerman, Head of the Aeronautical Engineering Department, has been designated to make a survey for "Air Uses of America." The survey is under Winthrop Rockefeller, New York City. Professor R. C. Jones, School of Architecture, was chosen to write a program for the Beaux-Art Institute of Design on the "School of Agriculture." These were sent to all the leading Eastern universities. Professor Jones was invited to come to Chicago for the judging on February 4.

Norwich University.—The Vermont State Legislature has granted Norwich University a general appropriation of $10,000 per

year to assist the bureau of industrial research and aid the engineering departments. This will be used to increase facilities for research and instruction by improving laboratory equipment, providing a laboratory technician, and increasing the teaching staff as conditions make this necessary.

The present catalogue of the University carries the following announcement, "A four weeks summer school will be held at the University (August 14 to September 13, 1939) to enable prospective students who have not had courses in solid geometry and trigonometry to make up those entrance conditions. This summer school provides a very definite service which makes possible the requirement that all engineering students must be free of conditions before they are eligible to matriculate."

The senior electrical engineers and the junior civil enginers have recently conducted a complete twenty-four hour test on the University heating plant. This is the first time such a project has been attempted and the results have been gratifying. The test was conducted for a dual purpose; first, for the experience and instruction of students in the power plants course, and second, for the information desired by the superintendent of buildings and grounds in order that changes or additions may be made more intelligently as they become necessary.

The investigating committee for the Engineer's Council for Professional Development, after the second visit has continued both the civil engineering and the electrical engineering departments on the approved list. In addition to the above items which tend to strengthen both courses special studies are being made in the field of soil mechanics. Some instruction is being given this year, and equipment for all basic tests will be available in the near future.

Arthur L. Cook has been appointed director of the **Pratt Institute School of Science and Technology.** Mr. Cook has been serving as acting director of the school since the death of Dr. S. S. Edmands on May 24, 1938.

Mr. Cook has been a member of the Institute faculty for 30 years and was head of the department of electrical engineering for 25 years before assuming the duties of acting director. He was graduated from Worcester Polytechnic Institute in 1901, received his master's degree in electrical engineering from the same Institution in June, 1903 and came to Pratt Institute in September 1903 as an instructor in applied electricity. In 1907, he left the Institute for a time to join the staff of Westinghouse, Church, Kerr and Company where he held the title of Electric Power Engineer. Returning to Pratt Institute in 1913, Mr. Cook was made head of

the department of electrical engineering and in 1919 was given the title of course supervisor in electrical engineering.

Mr. Cook is the author of "Elements of Electrical Engineering," a text book, used extensively in engineering colleges, and "Electric Wiring," a book for architects and engineers.

Stevens Institute of Technology.—The ninth annual economics conference of engineers will be held at the Stevens Institute Camp at Johnsonburg, N. J., June 24 to July 3. This conference is sponsored jointly by Stevens, the Management Division of the American Society of Mechanical Engineers, and the New York Section of the American Institute of Mining and Metallurgical Engineers. The interrelations of business and government will constitute the general theme of the conference.

The nine morning sessions will deal with Patent System, Wagner Act, Wages and Hours Law, Walsh-Healey Act, Taxation and other elements of Government affecting industry. The evening sessions will deal with Business and Government; An Orientation View, Enterprise vs. Authority as Principles of Economic and Social Progress, Government and the Business of Transportation, Program for Railroad Recovery, Labor Relations—the Railroads' No. 1 Problem, Current Approach to the Monopoly Problems, and others.

Tufts College.—On Sunday afternoon, March 26, 1939, a bas-relief of the late Dean Anthony was unveiled in Robinson Hall, Tufts College, in the presence of some fifty former Faculty associates and other friends of Dean Anthony. The beautiful sculpture, which is in old penny bronze, was created by Robert Reading, a pupil of the world famous Walter Russell. The bronze was donated to Tufts College jointly by the Trustees and by Mr. Charles P. Anthony, son of Dean Anthony. It is on the wall, near the head of the main staircase, on the second floor of Robinson Hall, in close proximity to the office of the Dean of the Engineering School.

The exercises at the unveiling were presided over by Dean Harry P. Burden of the Engineering School. The speakers were Dr. Lee S. McCollester, Dean (Emeritus) of the School of Religion at Tufts College, Dean Harry P. Burden, and Dr. Leonard Carmichael, President of Tufts College. Since illness prevented Mr. Charles P. Anthony from being present, Dean Burden asked the sculptor, Mr. Robert Reading, to assist him in the unveiling.

Massachusetts Institute of Technology.—In the January issue of the JOURNAL it was reported that the curriculum in Sanitary Engineering was to be discontinued. This was an error in re-

porting by the Institute. The course is to be continued as heretofore under the administration of the Department of Civil Engineering.

Through a grant from the Carnegie Corporation a Center of Mathematical Analysis is to be established under the direction of Professor S. H. Caldwell of the Department of Electrical Engineering. This Center of Mathematical Analysis is being founded to encourage and assist technological advance in all fields by making available to scientific institutions and industry the means for carrying out intricate mathematical processes economically. Equipment which will be available through the Center will include the present mechanical differential analyzer, the new electrical differential analyzer now nearing completion, the Cinema integraph, the network analyzer, the simultaneous calculator and other calculating machines.

Arrangements have been made for a program of ground instruction and flight training for twenty students in coöperation with the Civil Aeronautics Authority for the training of civilian pilots. Students will be selected by the Institute and finally approved by the C. A. A. from sophomore, junior, senior, and graduate students whose scholastic records indicate their ability to take the aeronautical training in addition to their formal course of studies at the Institute.

The Sylvanus Reed award for 1938, conferred annually by the Institute of the Aeronautical Sciences in recognition of a notable contribution to Aeronautical Engineering, was presented to Professor Alfred V. de Forest of the Department of Mechanical Engineering "for the development of a method generally used by the aircraft industry for testing metals magnetically," on January 27.

D. C. Jackson, Professor Emeritus of Electrical Engineering, was presented the Edison Medal by the American Institute of Electrical Engineers at the Mid-Winter Convention on January 25.

Vannevar Bush, who resigned as Vice-President on January 1 to accept the presidency of the Carnegie Institution of Washington, has been made a life member of the Corporation of the Institute. He was also awarded $2,500 in recognition of exceptional distinguished scientific achievement by the Research Corporation on February 2.

NECROLOGY

HUGO DIEMER, M.E., B.A., Director of Management Training, LaSalle Extension University, Chicago, since 1920, died suddenly, Friday, March 3, 1939, at the age of 69. He was prominent as an engineer, educator, and author.

Colonel Diemer taught at Michigan State College, the University of Kansas, and Pennsylvania State College.

A Major in the Ordnance Department during the World War, he served at the United States Cartridge Company, Lowell, Mass., in 1917, and at Bethlehem Steel Company, 1918. In 1919–20 he was Personnel Superintendent of the Winchester Repeating Arms Company. Since 1922 he held the rank of Lieutenant-Colonel in the United States Ordnance Reserve.

He was Chairman of the Chicago Section of the Taylor Society, 1924–25; President, Chicago Chapter, Society of Industrial Engineers, 1925, and National Vice-President, 1930–35; Chairman, Chicago Section, American Society of Mechanical Engineers, 1926–27; National Vice-President, Society for Advancement of Management; and one of the founders and first Chairman of the Chicago Management Council. In January, 1939, he was awarded the Taylor Key by the Society for the Advancement of Management in recognition of outstanding contributions to the science of management.

He was the author of five well-known books: "Factory Organization and Administration," "Industrial Organization and Management," "Modern Foremanship and Production Methods," "Wage Payment Plans," and "How to Set Up Production Control for Greater Profits."

Mr. Diemer has been a member of this Society since 1902.

BOOK REVIEWS

Circuits and Machines in Electrical Engineering by JOHN O. KRAEHENBUEHL AND MAX A. FAUCETT. John Wiley and Sons, Inc. 665 Pages. Price $4.50.

In "Circuits and Machines in Electrical Engineering" the authors have taken up the subject of Electrical Engineering by combining the concepts of alternating currents and direct currents. This eliminates the necessity of the student having to modify his concepts of direct current when he studies alternating current.

The first 14 chapters deals with Electrical Circuits. Chapter 15 is on Electronics. Chapters 16 to 29 inclusive takes up Electrical Machinery. The last chapter deals with the study of Electrical Illumination. The fundamentals in each chapter are amply illustrated by typical problems at the end of the chapter.

The text is written primarily for Non Electrical Engineering students who desire a fundamental knowledge of Electrical Engineering.

Theory and Applications of Electron Tubes by HERBERT J. REICH. McGraw-Hill Book Co., Inc. 668 Pages. Price $5.00.

The author has assembled a wealth of Electron tube material very logically in the 15 chapters that go to make up "Theory and Applications of Electron Tubes." There are 53 problems that illustrate the text material in 10 of the chapters.

A very good conception of the text material included in the book may be had from the chapter headings which are:

1. Physical Concepts.
2. Thermionic Emission. The High-Vacuum Thermionic Diode.
3. Grid-Controlled High-Vacuum Tubes.
4. Methods of Analysis of Vacuum Tubes and Vacuum-Tube Circuits.
5. Modulation and Detection.
6. Amplifier Definitions, Classifications, and Circuits.
7. Analysis and Design of Voltage and Current Amplifiers.
8. Class A and Class AB1 Power Amplifiers.
9. Class B and Class AB2, and Class C Amplifiers.
10. Vacuum-Tube Oscillators.
11. Electrical Conduction in Gases.
12. Glow- and Arc-Discharge Tubes and Circuits.

13. Light-Sensitive Tubes and Cells.
14. Power Supplies.
15. Electron-Tube Instruments and Measurements.

PHILIP E. RUSH

The Internal Combustion Engine. C. F. TAYLOR AND E. S. TAYLOR. International Textbook Company. 322 pp.

This book is an interesting discussion of the theory and performance of internal combustion engines of both the spark-ignition and compression-ignition types. The writers state that, "The treatment has been made as brief as practicable, as the authors believe it better to stimulate original thought and a desire for further study than to treat each subject exhaustively." In order to aid further study an extensive bibliography is included covering the topics treated in the book.

A large amount of experimental data is given in the form of typical curves which are thoroughly discussed. These are presented in such a way as to be valuable for design and practice as well as instruction. Six very useful charts are included in the form of inserts in the back of the book. The charts show the thermodynamic characteristics of "rich," "lean" and "chemically correct" fuel-air mixtures before combustion and the characteristics of the corresponding products of combustion.

No problems are included for students to work, but illustrative examples are included where needed. The object of the book, according to the authors, is to furnish a basic understanding of the functioning of the internal combustion engine which may serve as a foundation for design and research. It is the opinion of the reviewer that they have accomplished their purpose commendably.

THOS. G. BECKWITH

Direct Current Machinery by THOMAS MCFARLAND. International Text Book Company. 433 pages.

The book is written as a text for students majoring in Electrical Engineering. With this in mind, the author presents the basic fundamentals of electricity and magnetism in the first chapter together with suitable problems. General assembly of D. C. machines, armature windings, no load saturation curve and armature reaction constitute the next four chapters. The next nine chapters are given to the study of characteristics of generators, special types of generators, and motors. The last three chapters of the book cover efficiency commutation and installation.

The book contains problems at the end of each chapter which cover the material of that chapter. Graphical methods are pre-

sented for finding characteristics for the different types of machines. The chapter on Shunt Motor is noteworthy in that hand and automatic starters are well covered. An appendix and index are included. The book is well printed and is easily read. It should make an excellent text or reference in this field.

Principles of Electricity and Electromagnetism by G. P. HARNWELL. McGraw-Hill Book Company. 619 Pages.

The work is intended as an introduction to both experimental and theoretical electricity. It is written for those who are familiar with the basic experimental laws from an elementary course. A certain knowledge of fundamental mathematics is assumed and Vector notation is used when necessary. An appendix covers some of the differential equations and Vector concepts.

The field covered is vast in its content. Statics, dielectrics, circuits, chemical, thermal and photoelectric effects, vacuum tubes, conduction in gases, electromagnetics, magnetics, electric machinery, filters, vacuum tube circuits and radiation constitute the main divisions. To present a book of this scope which is knit into a compact whole is a considerable task. Problems are given at the end of each chapter which render the book very effective for teaching. Numerous diagrams and illustrations are found throughout the work.

In the opinion of the reviewer this book should set a standard for a work in this field.

R. W. AHLQUIST

Engineering's Part in the Development of Civilization by D. C. Jackson may be secured from the American Society of Mechanical Engineers, 29 West 39th St., New York City, $1.55 a single copy.

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MEMORANDUM ON CONFERENCE ON ACCREDITING PROBLEMS *

This conference was presided over by Dr. Zook, President of the American Council on Education, and was attended by nearly fifty members of twenty-six accrediting agencies, and also by President Tigert and several of the members of his committee appointed by the Land Grant College Association and the Association of State Universities to study the difficulties to which these institutions have been subjected as a result of the multiplicity of accrediting activities.

The discussion disclosed several different categories of accrediting agencies. First and most easily defensible in principle were accrediting agencies like E.C.P.D. and American Medical Association whose activities contribute toward meeting a requirement set up by state laws. Second are the regional and national accrediting agencies whose primary objectives are to identify those institutions which can coöperate on an approximate basis of equality as regards transfers of credit, etc., and which also operate to protect the public against the abuses of "diploma mills" and similar rackets. A third group is interested largely in limiting the output of students in given professions which are so seriously overcrowded as to create much hardship and disappointment among graduates. All of these agencies have a common objective of raising standards of education and educational procedure.

The discussion also disclosed extensive dissatisfaction and irritation on the part of educational administrators over the multiplicity of accrediting agencies, the financial burden of supporting their activities, the tendency of these agencies to put educational procedures into a strait-jacket, and the practice of requiring extensive information described by administrators as "unpertinent and impertinent." Suggestions had been made that powerful institutions combine to resist this movement, even to the extent of refusing all information and coöperation to accrediting agencies. It has also been suggested that the group of Land Grant and state universities set up their own accrediting agency for their own institutions and simply permit outside accrediting agencies to take or leave the results of their own procedures.

My impression is that these extreme measures are not imminent but that they, or something like them, may very easily come to pass

* This Conference was held under the auspices of the American Council on Education in Washington, D. C., April 7–8, 1939.

if something is not done to decrease or at least to prevent the increase of the types of burden and annoyance mentioned above. I therefore believe that our E.C.P.D. committee should sympathetically do everything in its power, consistently with performing its necessary function, to alleviate the difficulties of the situation.

I believe that the following suggestions are worthy of consideration by the delegatory committees or by the main committee on engineering schools.

1. In our re-inspections it would appear unnecessary for us to go into great detail in matters of general institutional administration, or finance, or service departments, unless there have been very considerable changes (for the worse) in these elements since the time of the first inspection.

2. We should keep constantly in mind our original basic principles of (*a*) avoiding specific minimum standards of any given element of the situation, (*b*) allowing the institution the maximum reasonable flexibility in its choice of educational philosophy and procedures, (*c*) being more concerned with the "end result" (as disclosed, for example, by final examinations) than with the procedures by which this end result is attained.

3. We should make every effort to give prompt and effective service to the officers of the institutions which ask our help or advice in improving their engineering departments. In my judgment an appreciable portion of the present "revolt" against accrediting in general arises from personal irritations. In so far as I have had any knowledge of irritations produced by our E.C.P.D. accrediting program, these have in large majority been complaints over the inability of college administrators to secure answers to letters which have been written to members of our own committee asking for information or advice.

A large portion of the Washington conference was devoted to the discussion of proposals for eliminating duplication between various accrediting agencies. While much was done to clarify the situation, the only suggestions which seemed to me at all pertinent or helpful to our E.C.P.D. program were to the effect that we might make greater use than we have thus far made of information which has been collected by other accrediting agencies as, for example, on the library, administration, finances and quality of service departments. I shall explore further the possibility of taking advantage of existing information along these lines, though I doubt whether even this is very pertinent to our case, since our initial accrediting program is practically completed and the occasional re-inspections should not require much exploration into service departments or administration unless there have been notable changes.

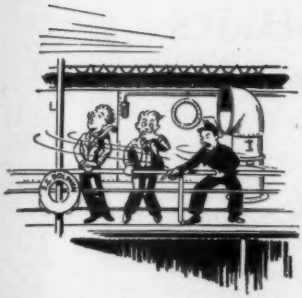
It was reported that some of the other important accrediting agencies, such as the North Central Association, are accepting the findings of our committee with respect to the engineering departments.

I had a very interesting and satisfactory discussion with the two representatives of the New York State Department of Education, Mr. Milton Loomis, Associate Commissioner, who has just succeeded Mr. Horner, and Mr. Irwin A. Conroe, Director of Education.

KARL T. COMPTON, *Chairman*,
Committee on Engineering Schools, E.C.P.D.

April 17, 1939.

G-E Campus News



FLOATING POWER

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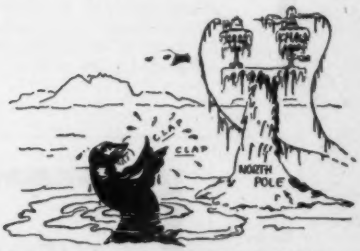
The meter is essentially a combination of two electric generators mounted a little distance away from each other on the propeller shaft, and connected to instruments which can be located at any point on the ship. The generators are so mounted that at no load the voltages generated are exactly 180 degrees apart in phase and therefore add to zero.

When a load is placed on the revolving shaft, the torque causes a small angular twist in the shaft; consequently, the two generated voltages no longer add to zero. The resultant voltage is proportional to both the shaft twist and the propeller speed, and hence the meter can be made to read directly in horsepower. The installation can easily be modified to indicate total horsepower-hours and to write an automatic log of the power delivered during the trip.

Among the G-E engineers who developed the device are A. V. Mershon, Pratt Institute '13 and Union College '15, and C. I. Hall, U. of Illinois '10.



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